GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT INITIATION

Date: 7/21/78

Project Title: Specialized Engineering Services

Project No: A-2160

Project Director: Mr. E. E. Weaver

Sponsor: Hq. Warner Robins Air Logistics Center (WR-ALC/MMRPB) Robins AFB, GA. 31098

Agreement Period: From 6/14/78 Until 7/31/78

Type Agreement: Contract No. F09603-78-M-5048

S

Amount: $4,927

Reports Required: Monthly and Final Service Engineering Reports

Sponsor Contact Person (s):

Technical Matters

Mr. David W. Hank
Equipment Specialist
Technical Support Section
Attn: WR-ALC/MMRPB
Robins AFB, GA 31098
Phone: (912) 926-5911

Contractual Matters
(thru OCA)

ONRRR
Campus

Defense Priority Rating: DO-A7

Assigned to: Systems and Techniques Laboratory (School/Laboratory)

COPIES TO:

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- Division Chief (EES)
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- Project Code (GTRI)
- Other

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: August 29, 1978

Project Title: Specialized Engineering Services

Project No: A-2160

Project Director: Mr. E. E. Weaver

Sponsor: Hq. Warner Robins Air Logistics Center (WR-ALC/MMRPB)Robins AFB, GA 31098

Effective Termination Date: 7/31/78

Clearance of Accounting Charges: 7/31/78

Grant/Contract Closeout Actions Remaining:

S

TERMINATED

X Final Invoice

_ Final Fiscal Report

_ Final Report of Inventions

_ Govt. Property Inventory & Related Certificate

_ Classified Material Certificate

_ Other _____

Assigned to: Systems & Techniques Laboratory (School/Laboratory)

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Project File (OCA)
Project Code (GTRI)
Other _____

CA—4 (3/76)

FINAL ENGINEERING REPORT

PROJECT A-2160-000

SPECIALIZED ENGINEERING SERVICES

By

E. E. Weaver

Prepared for

HEADQUARTERS
WARNER ROBINS AIR LOGISTICS CENTER
(WR-ALC/MMRPB)
ROBINS AFB, GEORGIA 31098

CONTRACT NO. F0960378M5048

1 AUGUST 1978

GEORGIA INSTITUTE OF TECHNOLOGY

Engineering Experiment Station

Atlanta, Georgia 30332

1978

FINAL ENGINEERING REPORT
PROJECT A-2160-000

SPECIALIZED ENGINEERING SERVICES

By

E. E. Weaver

1 August 1978

Contract No. F0960378M5048

Prepared For

Headquarters
Warner Robins Air Logistics Center
(WR-ALC/MMRPB)
Robins AFB, Georgia 31098

Submitted by

Electromagnetic Effectivness Division
Systems and Techniques Laboratory
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

FORWARD

This program was carried out by personnel of the Systems and Techniques Laboratory of the Engineering Experiment Station at the Georgia Institute of Technology, Atlanta, Georgia 30332 with E. E. Weaver serving as Project Director. The program, which was sponsored by the Warner Robins Air Logistics Center was designated by Georgia Tech as Project A-2160-000.

This work was made possible through the combined efforts of many people at Robins Air Force Base and Georgia Tech. The author acknowledges the contributions of Joseph Smarr and John Louth of Robins Air Force Base/MMRREC and Stephen Gildner, Alan Murray, and Bill Warden of Georgia Tech to the success of the research program.

Respectfully submitted,

E. E. Weaver
Project Director

Approved:

Fred L. Cain
Chief,
EM Effectiveness Division

TABLE OF CONTENTS

LIST OF FIGURES

Figure | Page

SECTION I
INTRODUCTION

This program was established through Robins Air Force Base/MMRREC to give preliminary "quick turn around" type information to the Air Force regarding three types of antennas. These antennas were purchased either under different specifications or from different vendors and are designated as AST 1503, AST 1492, and AM 423. The system that employs these antennas uses more than one in a balanced network; therefore, it is necessary that the electrical characteristics of each antenna be matched within the sensitivity of the system. Therefore, the goal of this contract is to measure the response of each antenna and furnish these measured patterns to the Air Force.

However, the "quick turn around" nature of this contract does not allow extensive measurements of each antenna but rather selected measurements that would be indicative of the overall trends. Therefore, engineering judgment was used to select which antenna configurations, polarizations, and frequencies would be measured. The antenna configurations selected for pattern measurements were:

(1) azimuth plane - with radome,
(2) azimuth plane - without radome,
(3) vertical plane - with radome, and
(4) vertical plane - without radome.

Antenna patterns were recorded on each antenna configuration for (1) horizontally-polarized signals, (2) vertically-polarized signals, and (3) each of four frequencies designated as A+5, C, G, and K.

The following section of this report will describe the measurement procedures, present the data, discuss the results, and make recommendations for a more extensive analysis program.

SECTION II

MEASUREMENT PROCEDURES

The Georgia Tech Phase Center range was used to record the appropriate patterns of the designated antennas for each test condition. The phase center range consists of (1) a table with a movable top that can be positioned by two orthogonal feed screws, (2) a turntable with a long boom for mounting the receive antenna, and (3) the appropriate signal source, receiving equipment, and pattern recorder. The phase center range measures the response of antennas by moving a receiving antenna (mounted on and above the boom) on a circle about the test antenna. The received power is plotted as a function of the azimuth angle. Figure 1 is a schematic illustration of the phase center range and associated equipment.

In order to set the isotropic level on each pattern and to correlate the antenna gain, the following procedure was used.

1. A standard gain horn that is calibrated for the desired frequency was mounted on the phase center table and the RF leads connected.
2. The precision waveguide attenuator was set to the gain of the standard gain horn.
3. The receiver and recorder gains were adjusted so that the peak of the pattern of the standard gain horn was on the -10 dB level of the recorder paper. This procedure establishes -10 dB on the chart as the level of an isotropic radiator.
4. The attenuator was reset to 0 dB.
5. The test antenna was substituted for the standard gain horn and the desired patterns were recorded for that frequency and polarization.
6. The standard gain horn was substituted for the test antenna and the attenuator was reset to the gain of the standard gain horn.
7. The pattern of the standard gain horn was remeasured to insure accurate calibration throughout the measurements. If the peak of the standard gain horn in Step 7 was on the -10 dB level of the recorder paper, the data set was considered good data and kept. Otherwise, the data were remeasured.

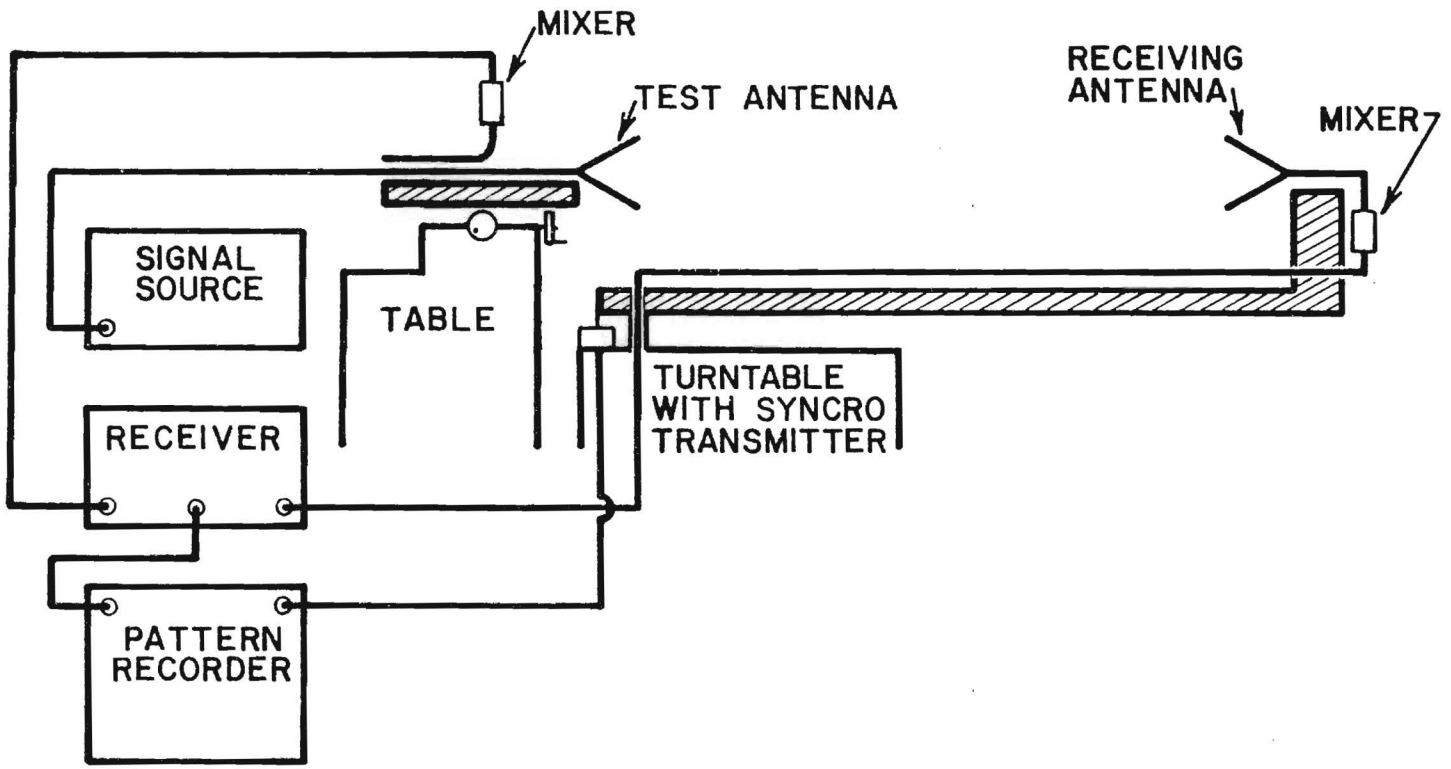


Figure 1. Schematic representation of test set-up on Phase Center Range.

When a run was completed, the range was configured for the next frequency, polarization, or test antenna, and the procedures were repeated until the measurements were completed. It should be noted that the phase center range turntable rotates in an azimuth plane only. Therefore, to simulate an elevation plane measurement, the test antenna was rotated 90 degrees about its boresight axis; furthermore, the polarization of the receive antenna must be rotated in similar fashion. As an example, a vertically-polarized elevation plane measurement when rotated corresponds to a horizontally-polarized azimuth plane measurement. However to avoid potential errors, the polarization was recorded on the recorded pattern exactly as it was measured. Therefore, the test conditions labeled [V-cut, V-pol] in the top corner of the measured patterns simulate a vertical plane cut, horizontal polarization. The actual operating situation simulated by the measurement is noted on the labels that appear in the lower center of each measured pattern.

SECTION III
RESULTS

The antenna patterns presented in this section in Figures 2-49 are the results of the measurements outlined in Sections I and II. As previously discussed, these patterns represent the performance of the AST-1492, AST-1503, and AM-423 antennas for the frequency ranges designated as A+0.5, C, E, and K. Each of these patterns were measured under the procedures described in Section II. These procedures fix the isotropic level for each pattern at the 10 dB level on the chart paper and thus each pattern can be compared relative to isotropic gain. Since the isotropic level is fixed at the same point on each pattern, all antenna gains can be determined by comparing the pattern levels as recorded on the chart paper.

The patterns presented in Figures 2-49 are ordered first by frequency, then by antenna, polarization, and plane cut.

Figure 2. Antenna pattern for:

ANTENNA..... AM 423

FREQUENCY... A+0.5

POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]

ELEVATION PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

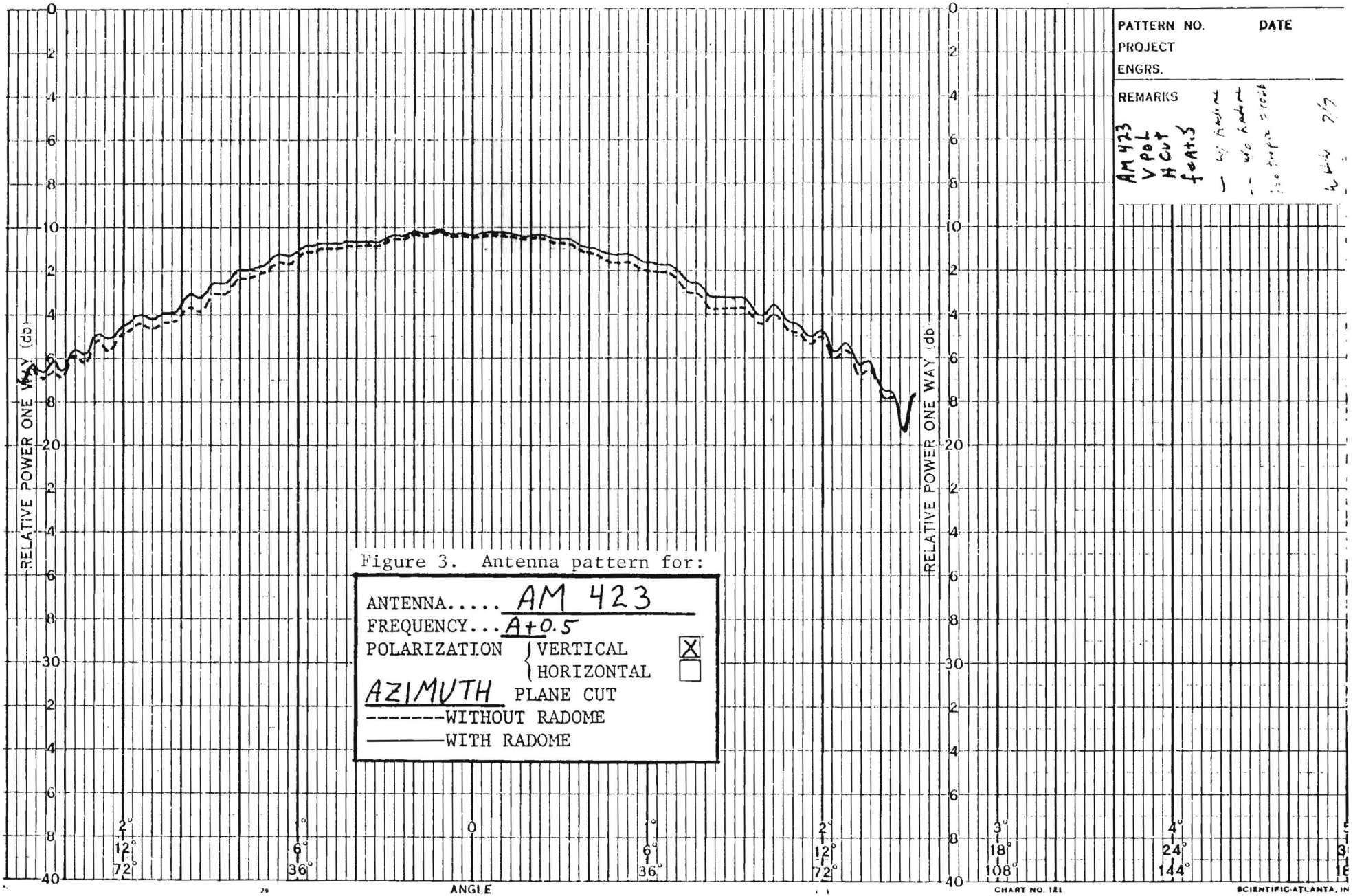


Figure 3. Antenna pattern for:

ANTENNA..... AM 423

FREQUENCY... A+0.5

POLARIZATION { VERTICAL [X] / HORIZONTAL [ ]

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

Figure 4. Antenna pattern for:

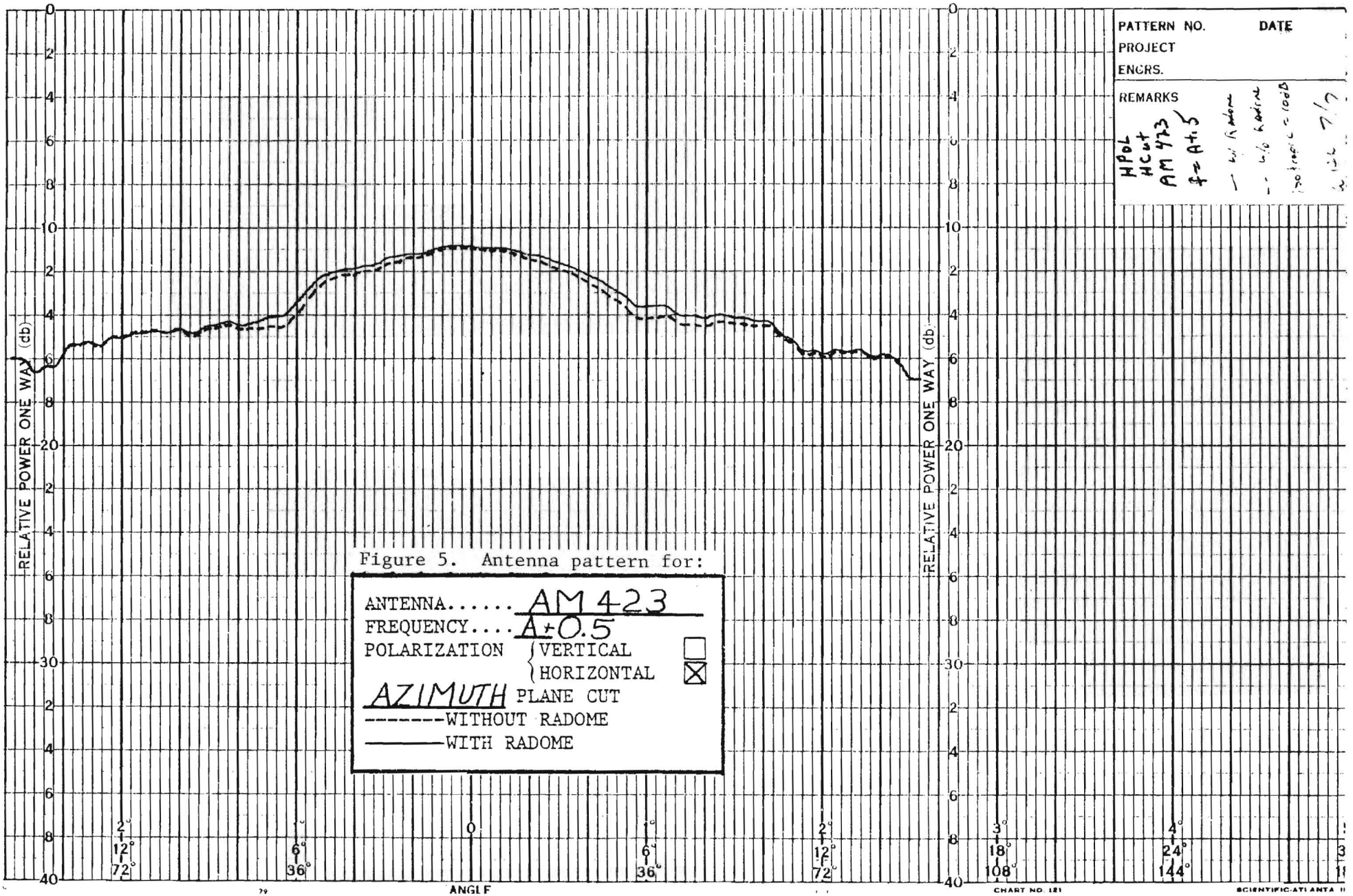


Figure 5. Antenna pattern for:

ANTENNA..... AM 423
FREQUENCY.... A±0.5
POLARIZATION { VERTICAL ☐
HORIZONTAL ☒

AZIMUTH PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

Figure 6. Antenna pattern for:

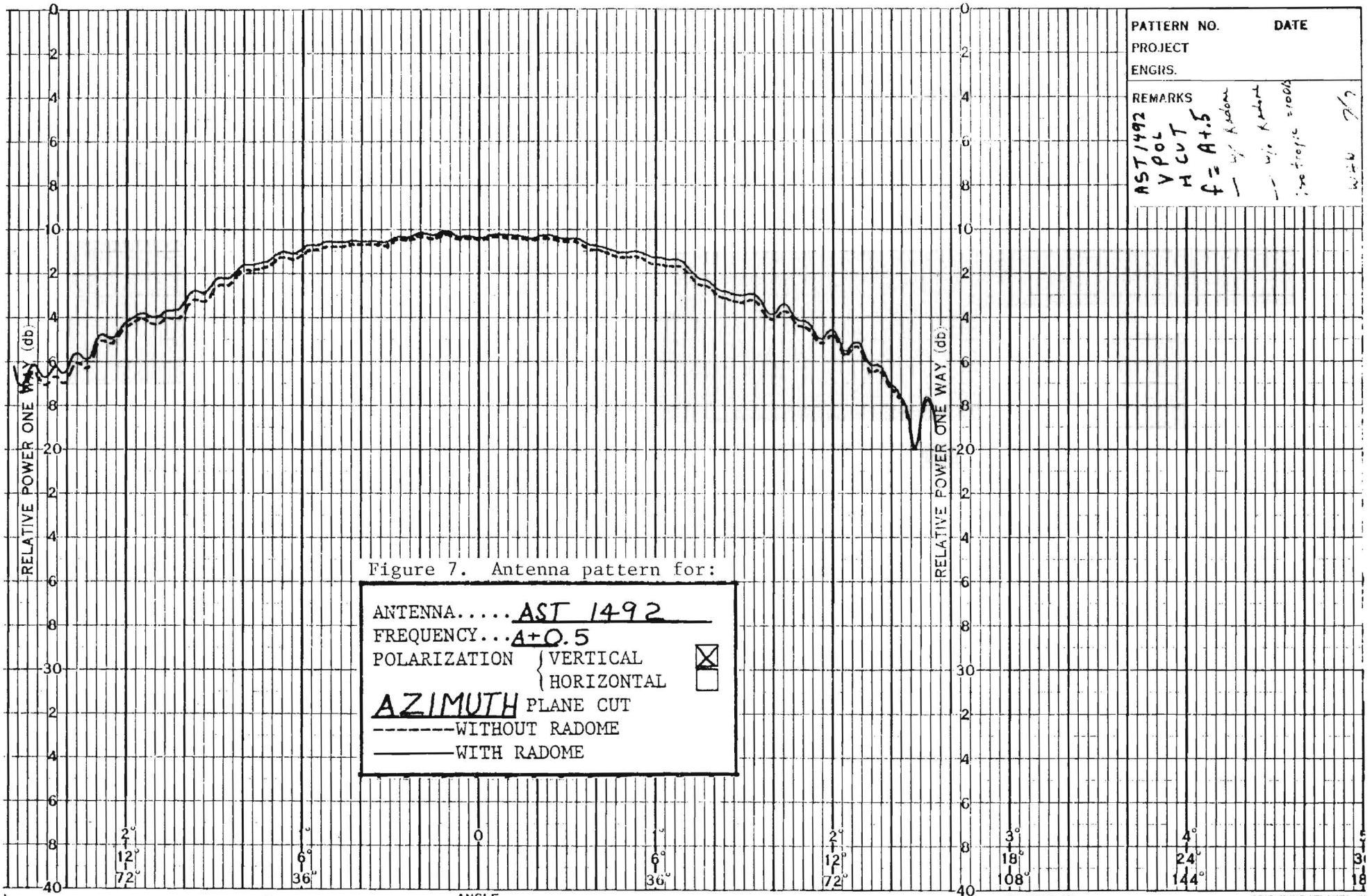


Figure 7. Antenna pattern for:

Figure 8. Antenna pattern for:

ANTENNA..... AST 1492
FREQUENCY.... A+0.5
POLARIZATION { VERTICAL ☐
HORIZONTAL ☒
ELEVATION PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

Figure 9. Antenna pattern for:

ANTENNA..... AST 1492

FREQUENCY.... A+0.5

POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

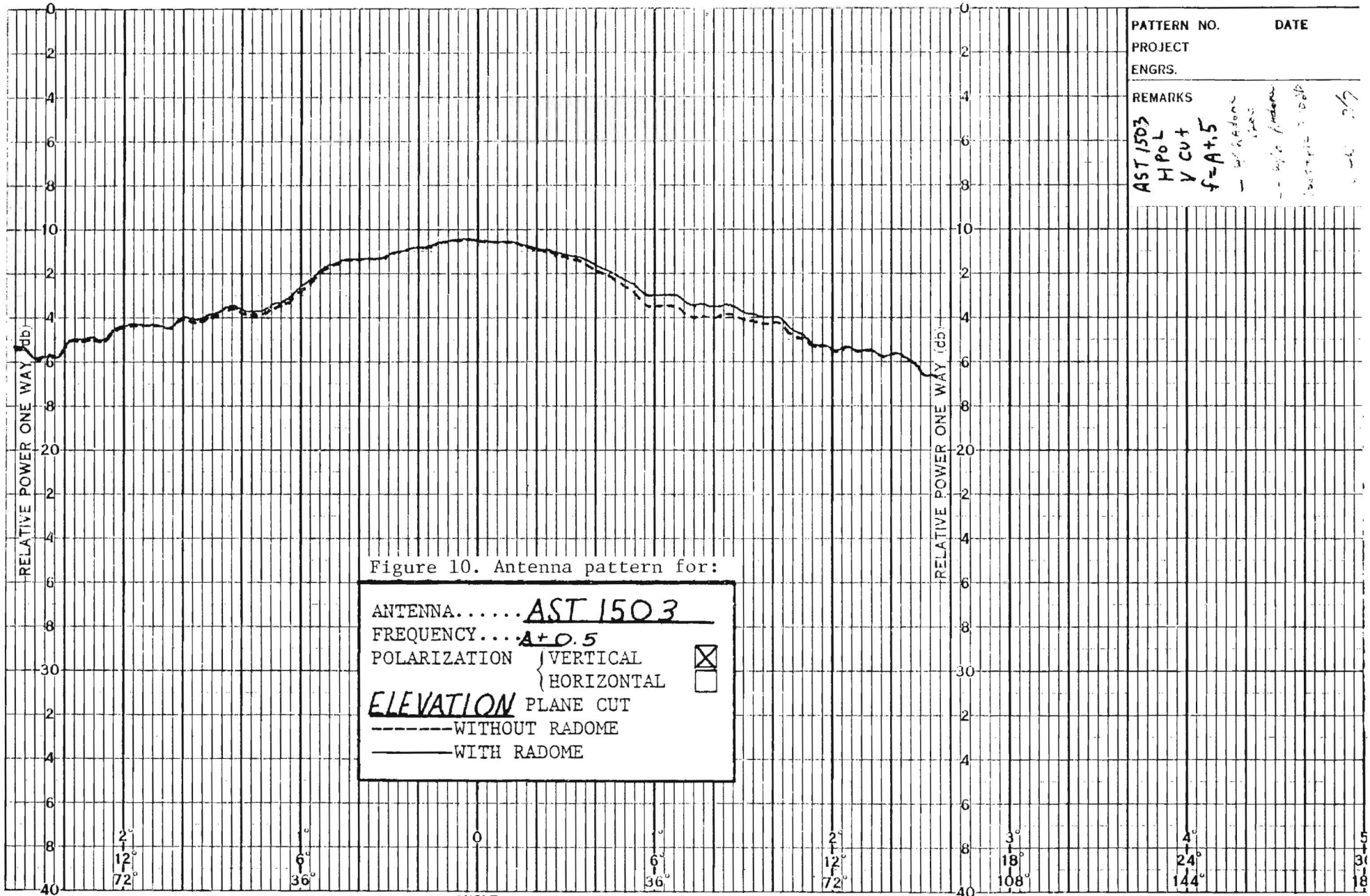


Figure 10. Antenna pattern for:

Figure 11. Antenna pattern for:

ANTENNA..... AST 1503

FREQUENCY... A+0.5

POLARIZATION { VERTICAL [X] / HORIZONTAL [ ]

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

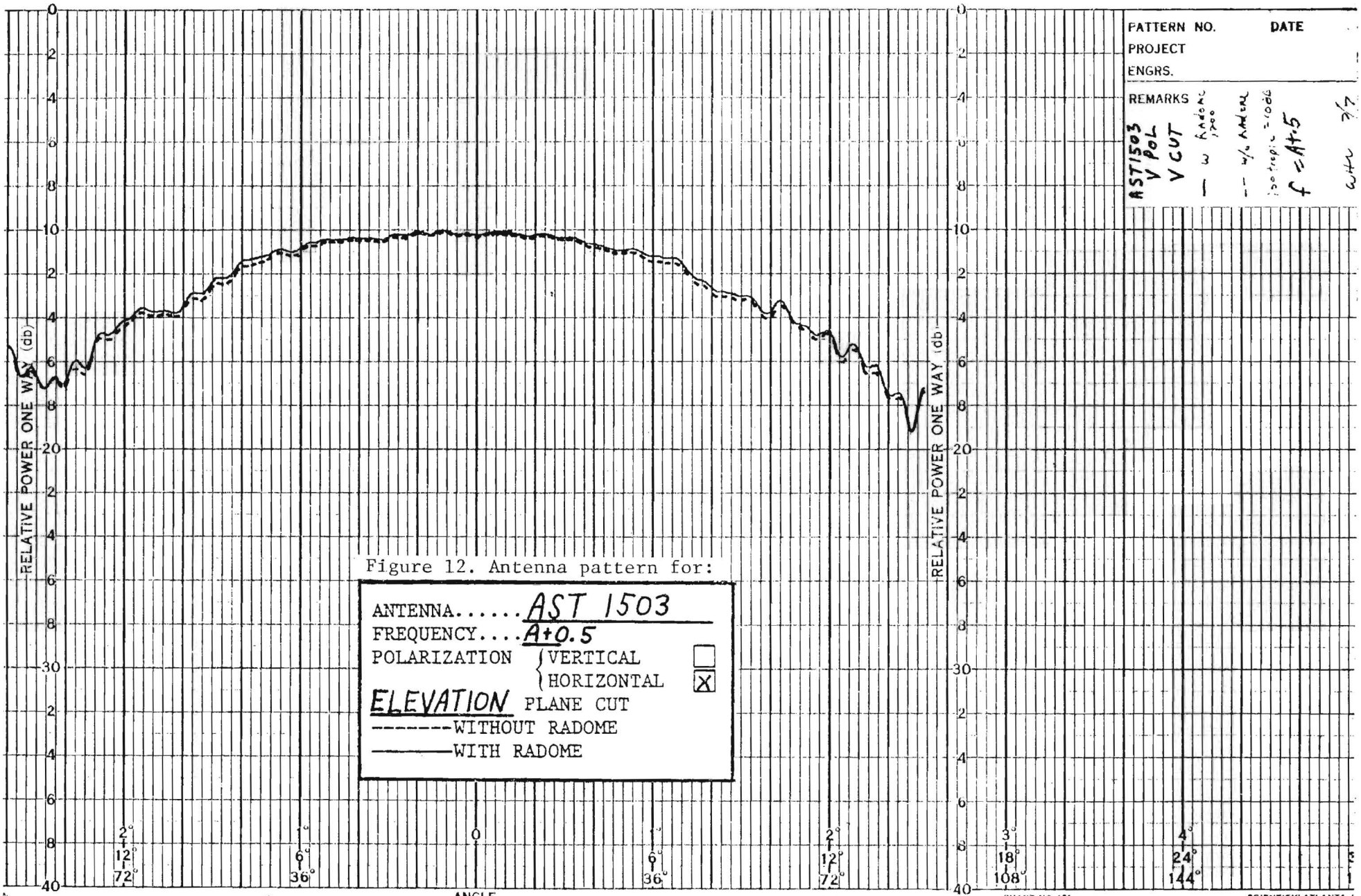


Figure 12. Antenna pattern for:

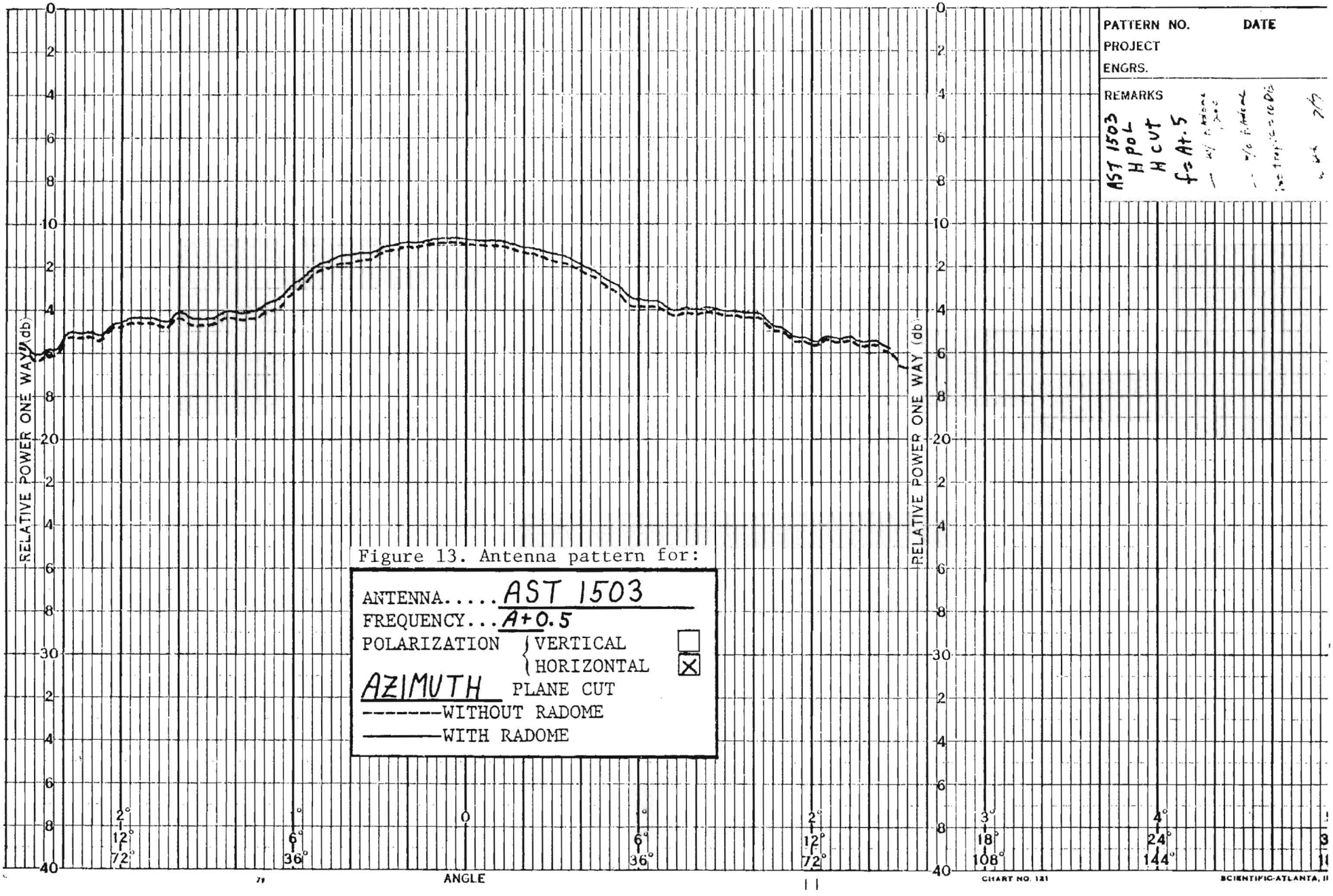


Figure 13. Antenna pattern for:

ANTENNA.....AST 1503
FREQUENCY...A+0.5
POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

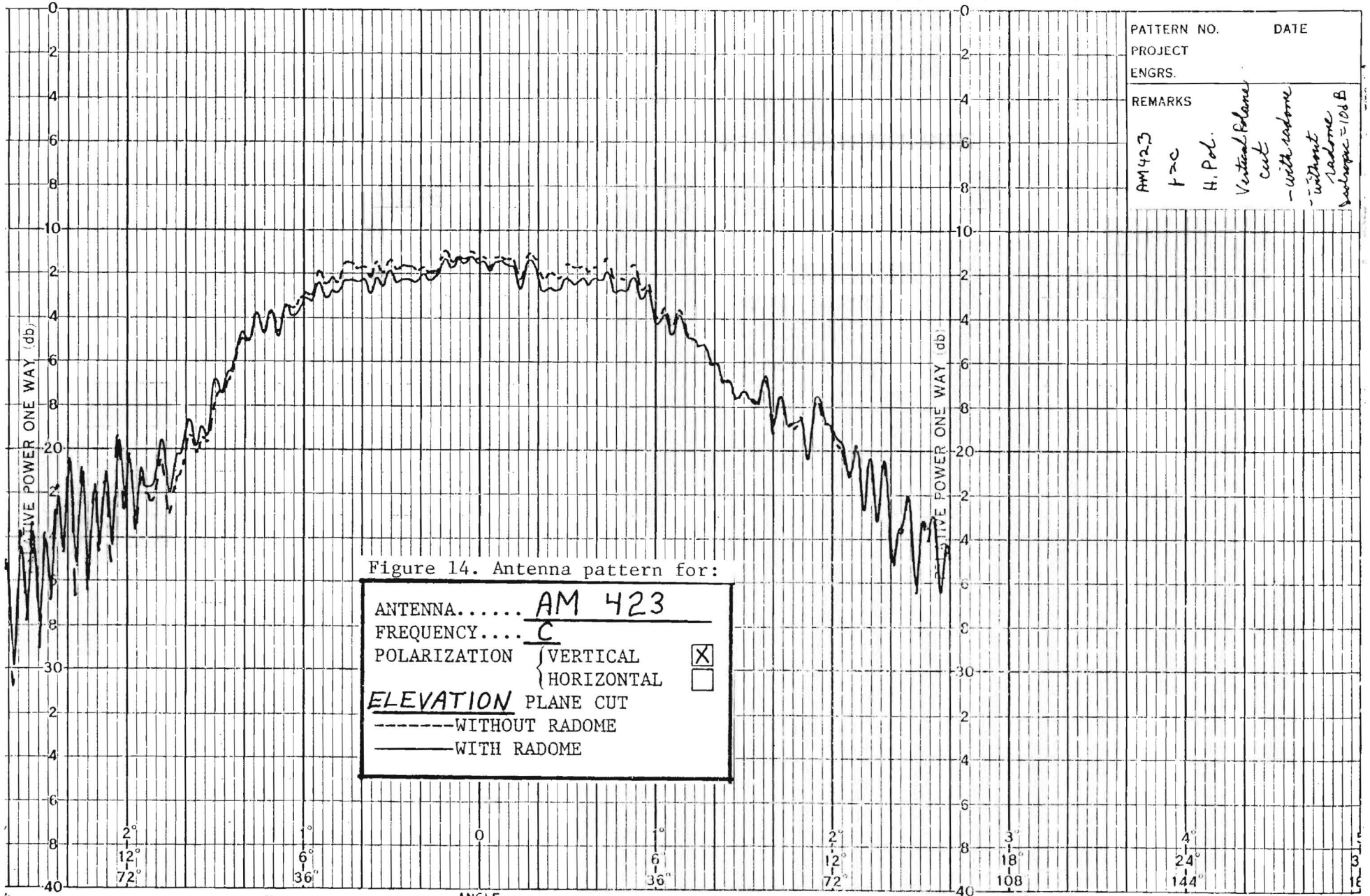


Figure 14. Antenna pattern for:

ANTENNA..... AM 423

FREQUENCY.... C

POLARIZATION { VERTICAL [X] / HORIZONTAL [ ]

ELEVATION PLANE CUT

--------WITHOUT RADOME

————WITH RADOME

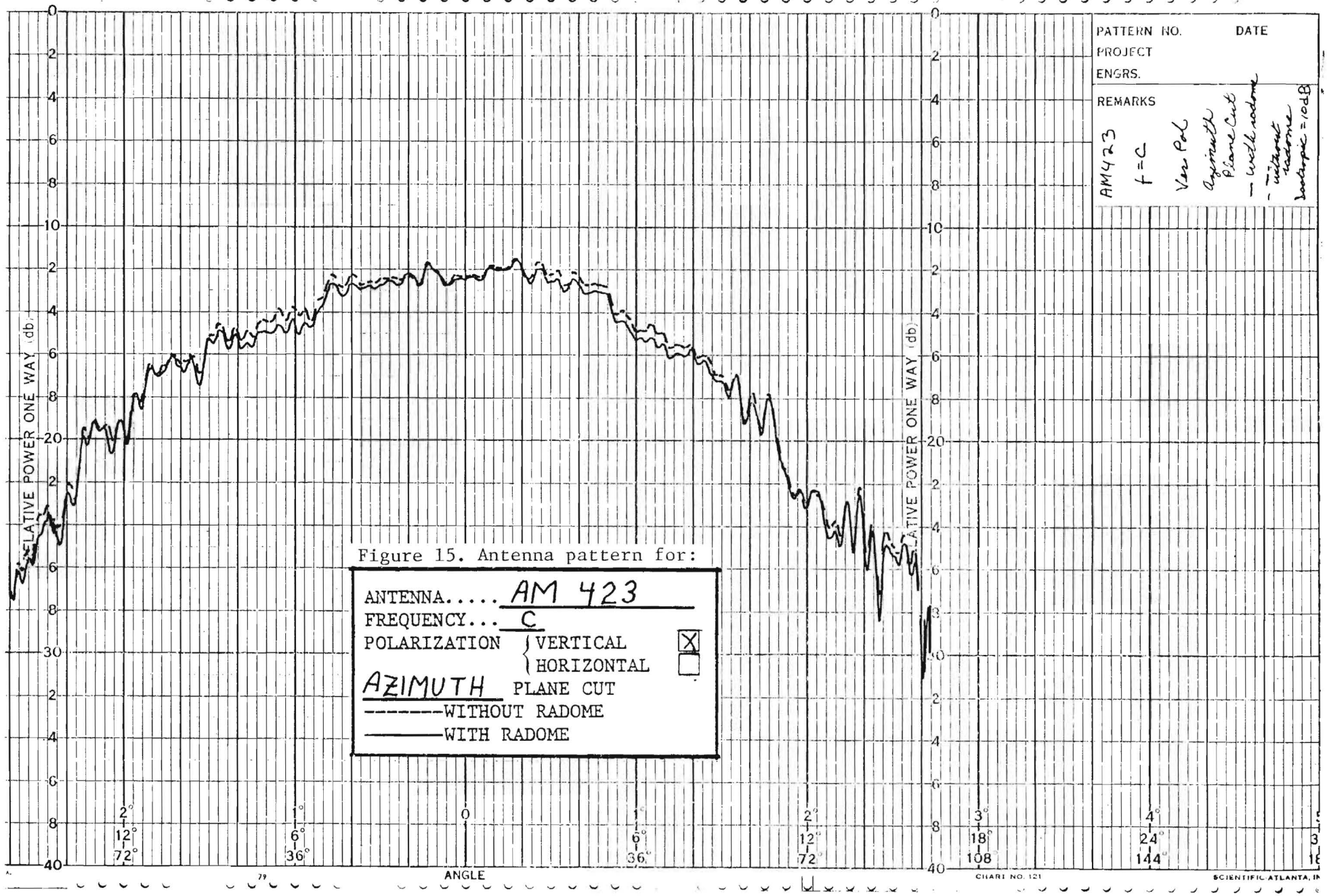


Figure 15. Antenna pattern for:

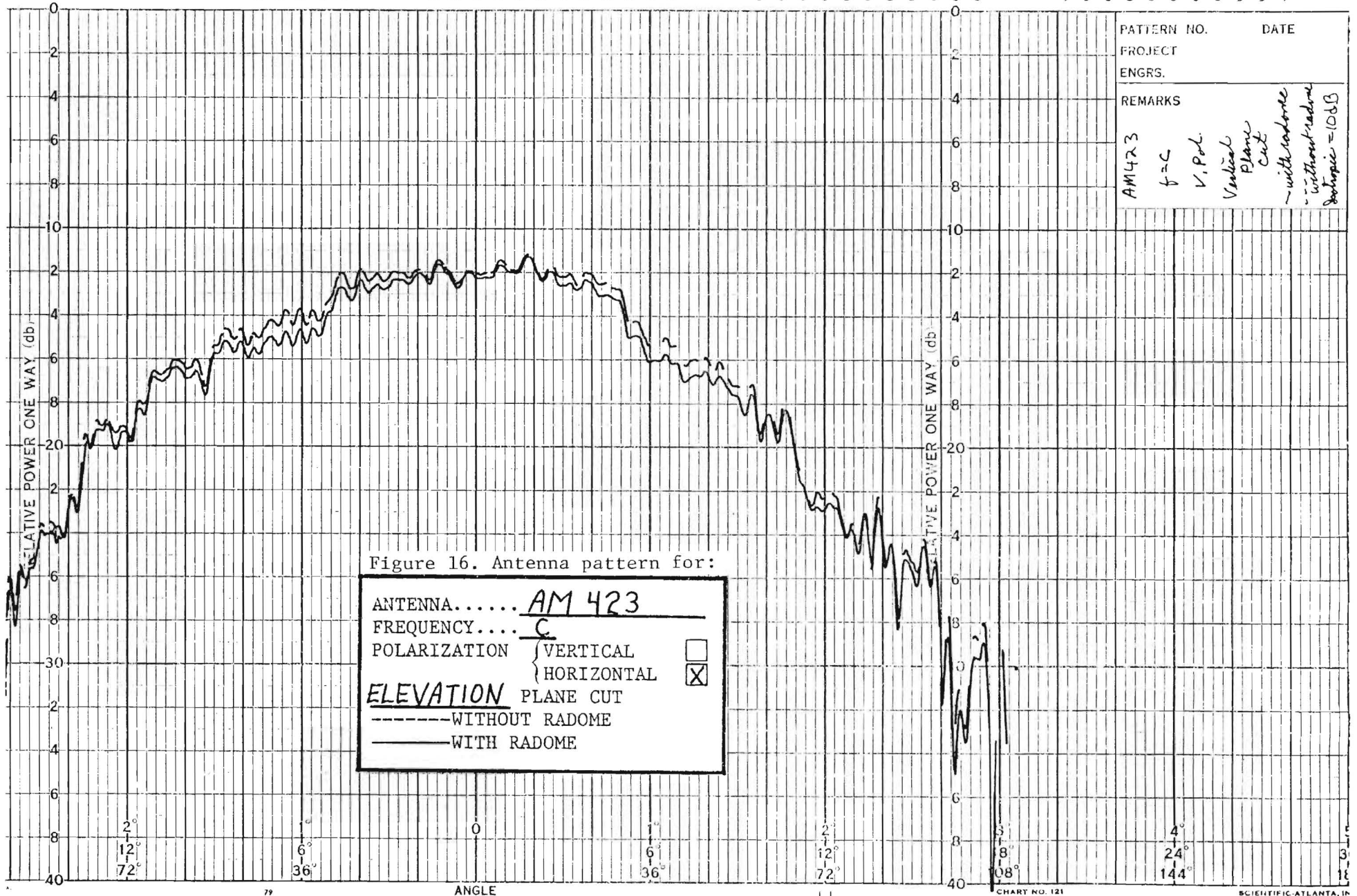


Figure 16. Antenna pattern for:

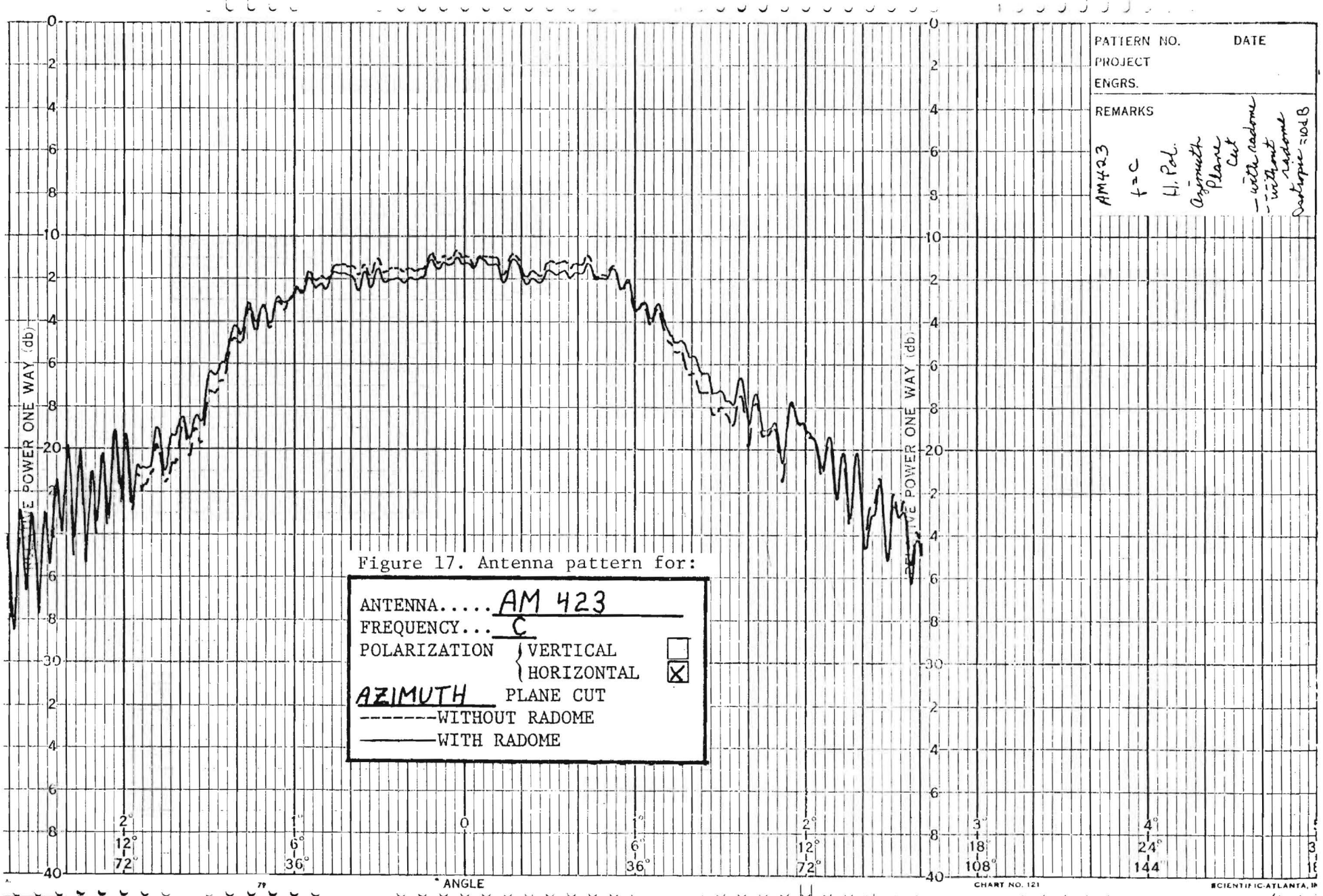


Figure 17. Antenna pattern for:

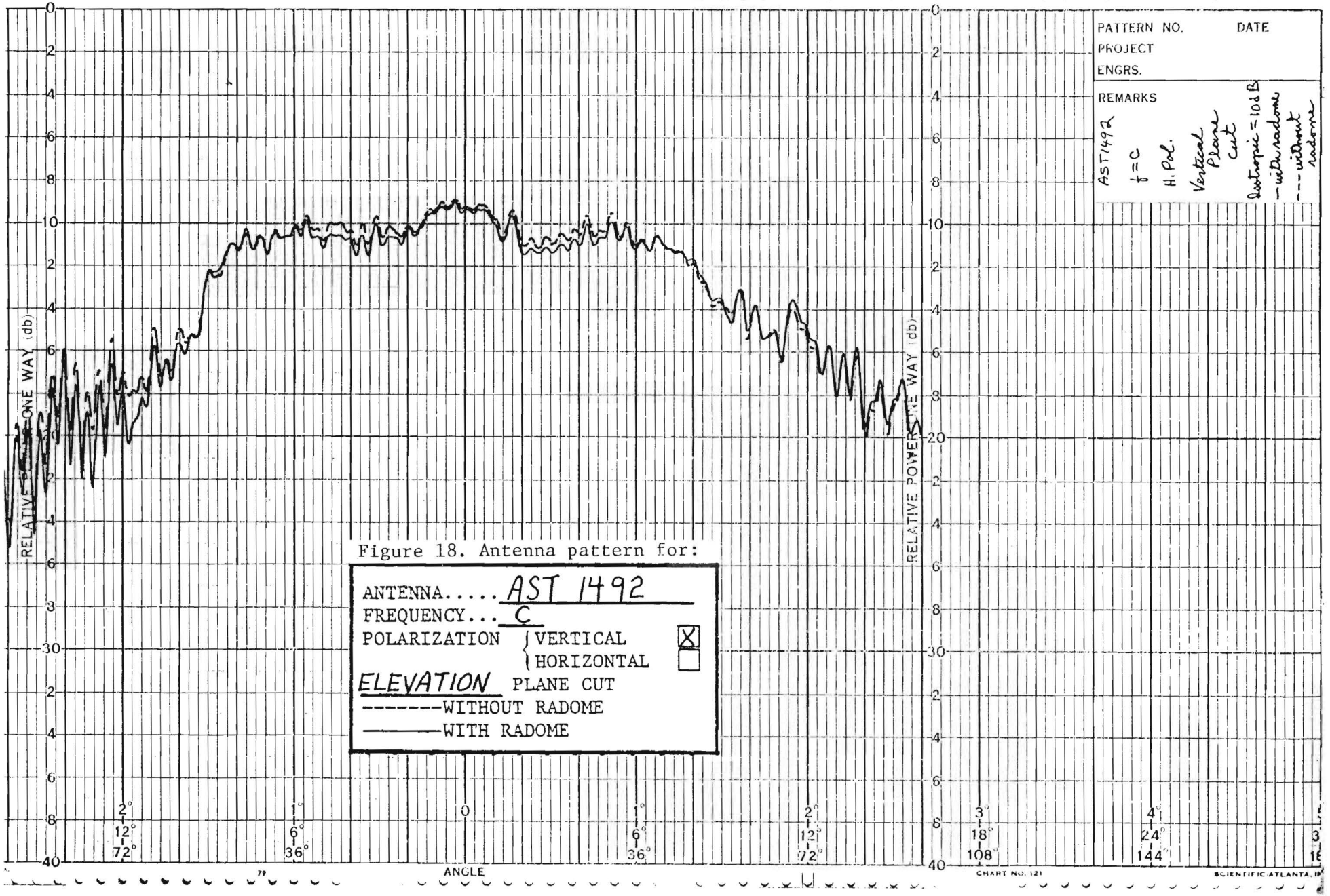


Figure 18. Antenna pattern for:

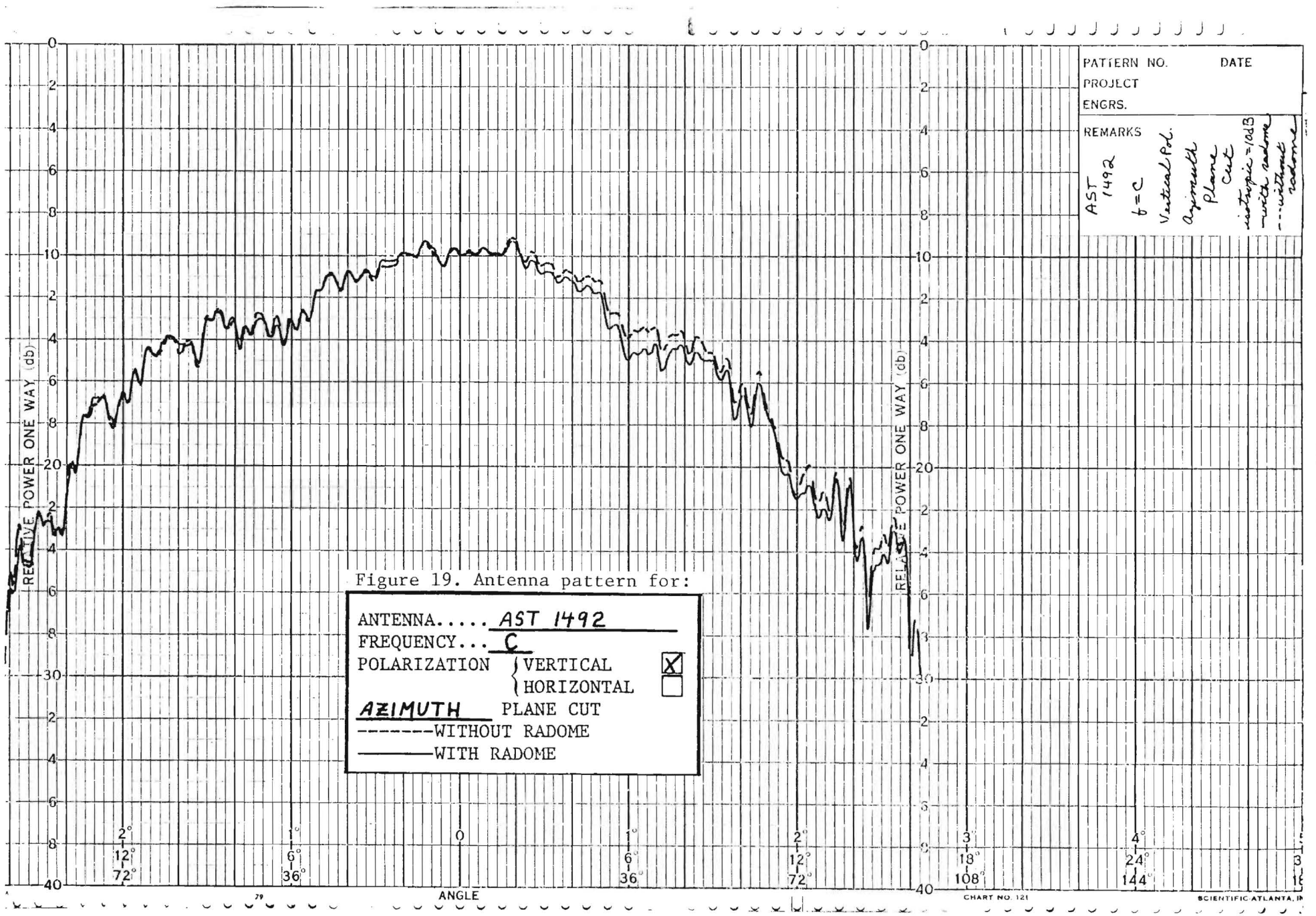


Figure 19. Antenna pattern for:

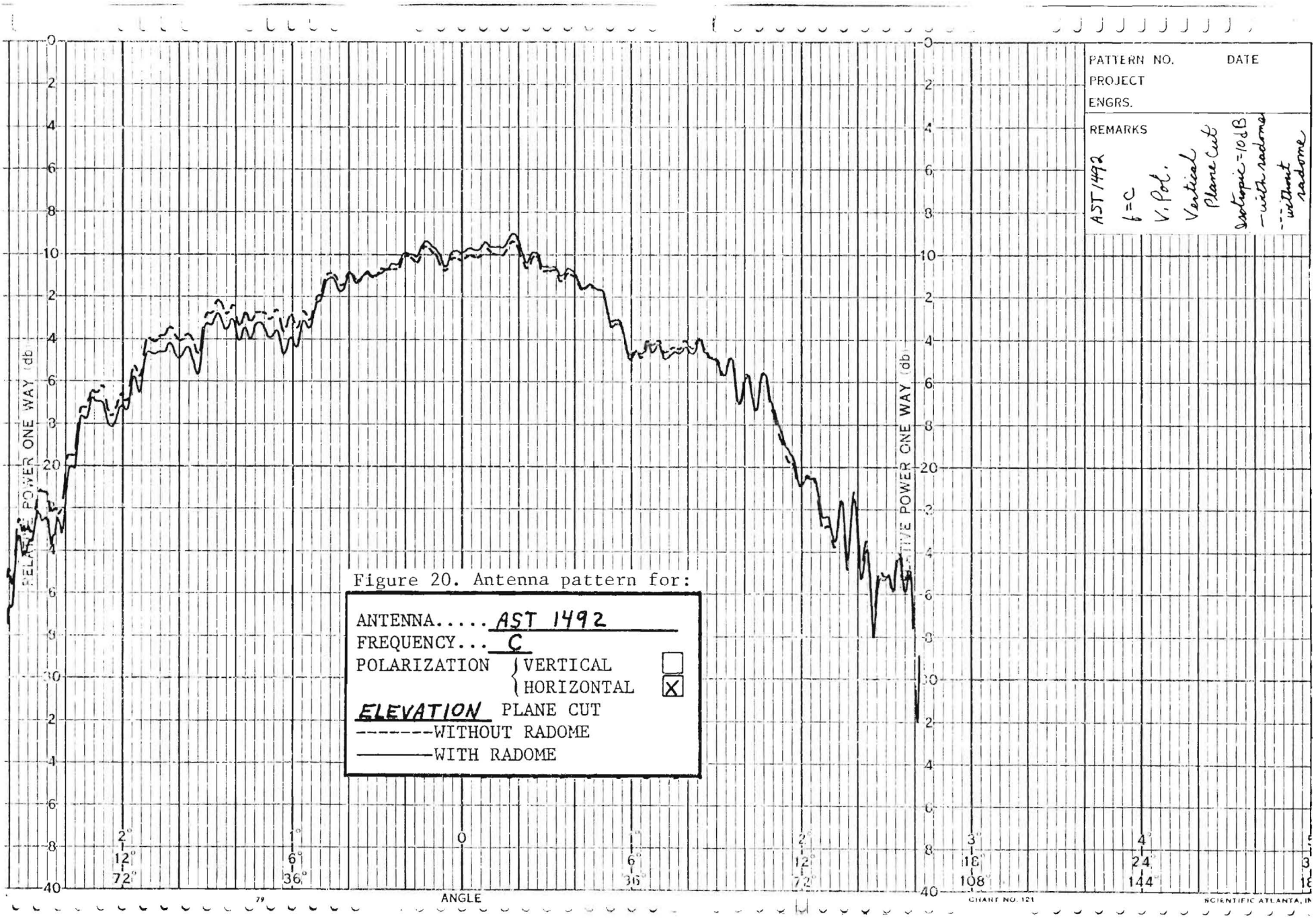


Figure 20. Antenna pattern for:

ANTENNA..... AST 1492
FREQUENCY... C
POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

ELEVATION PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

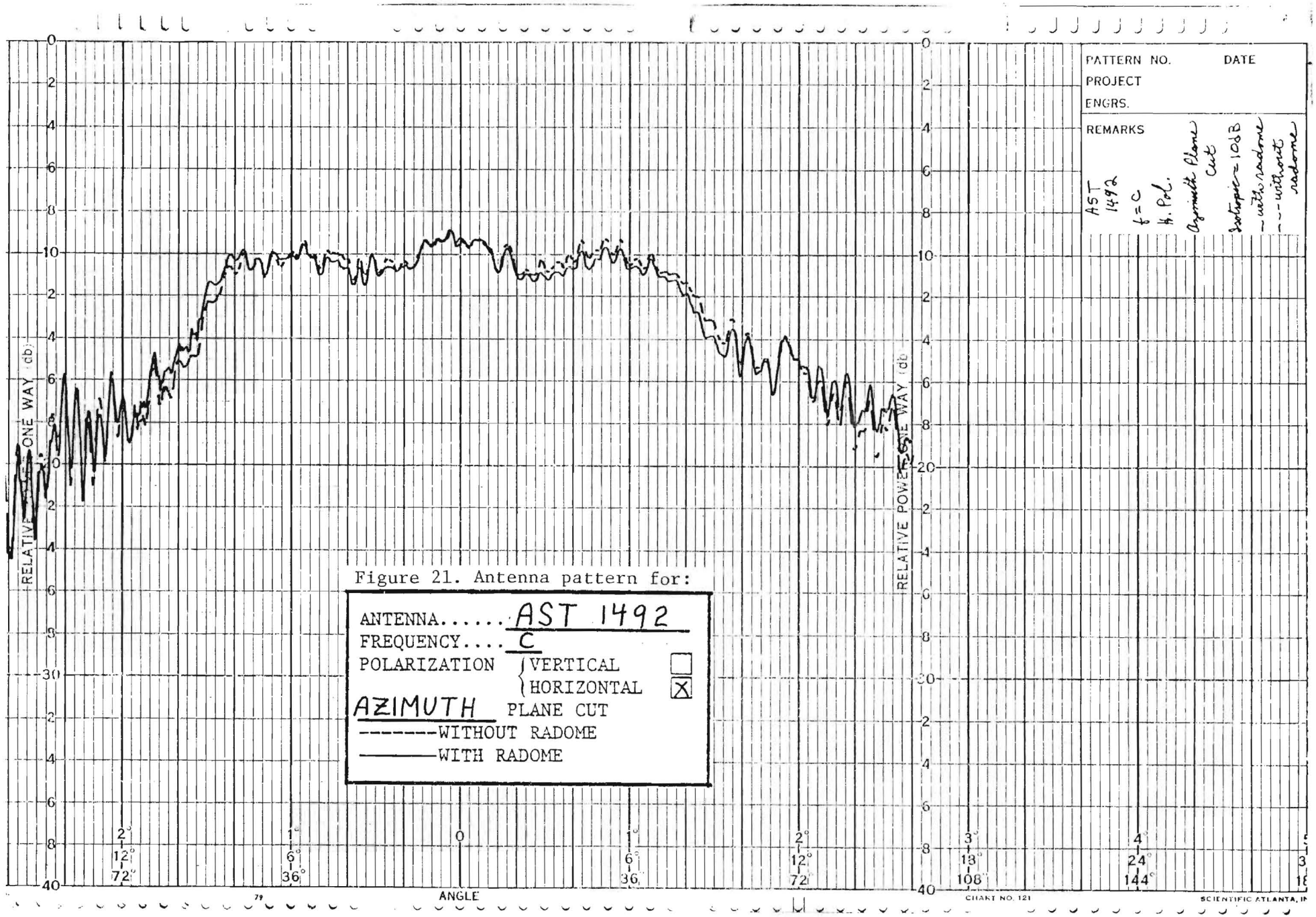


Figure 21. Antenna pattern for:

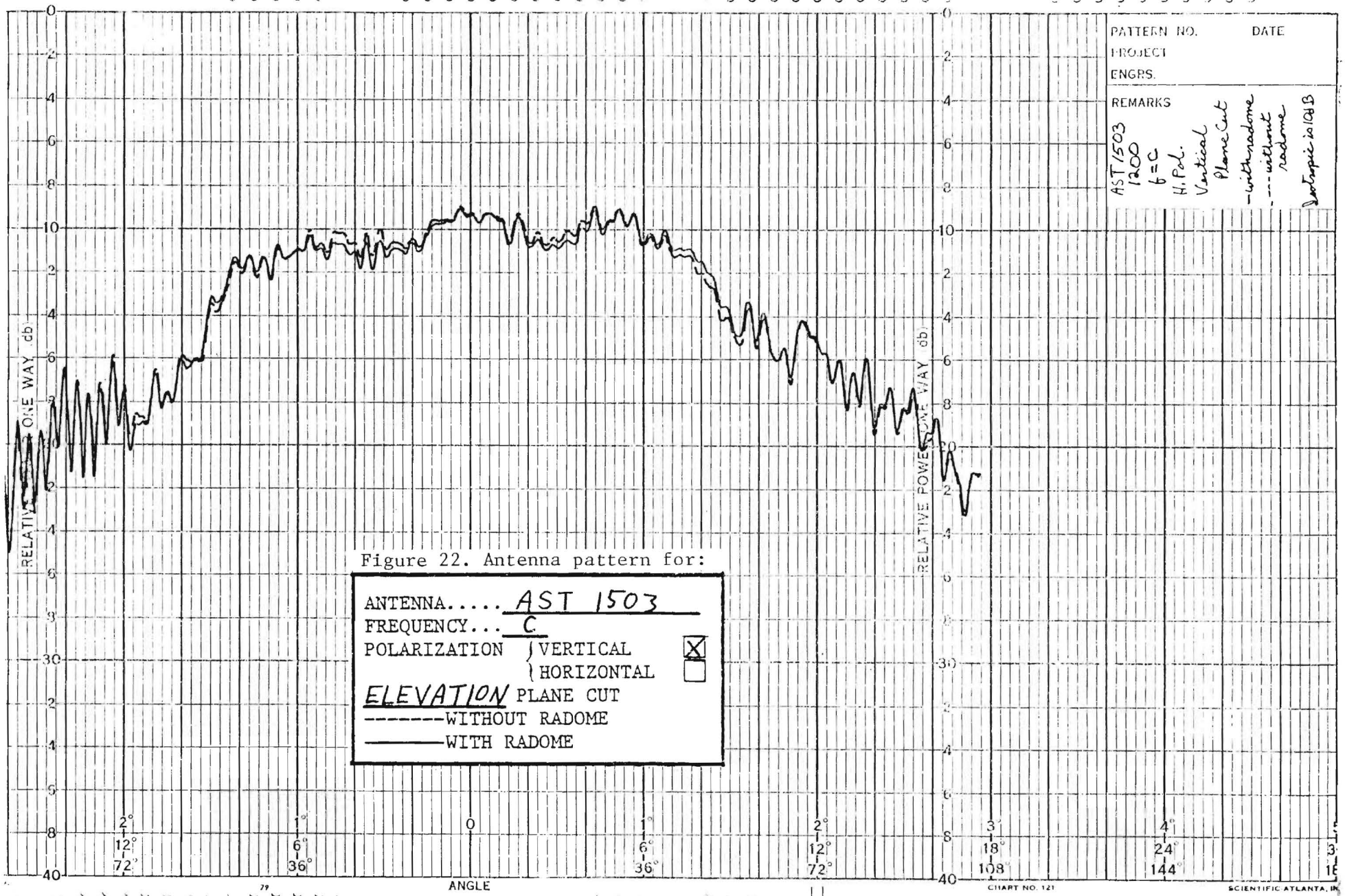


Figure 22. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY... C
POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]
ELEVATION PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

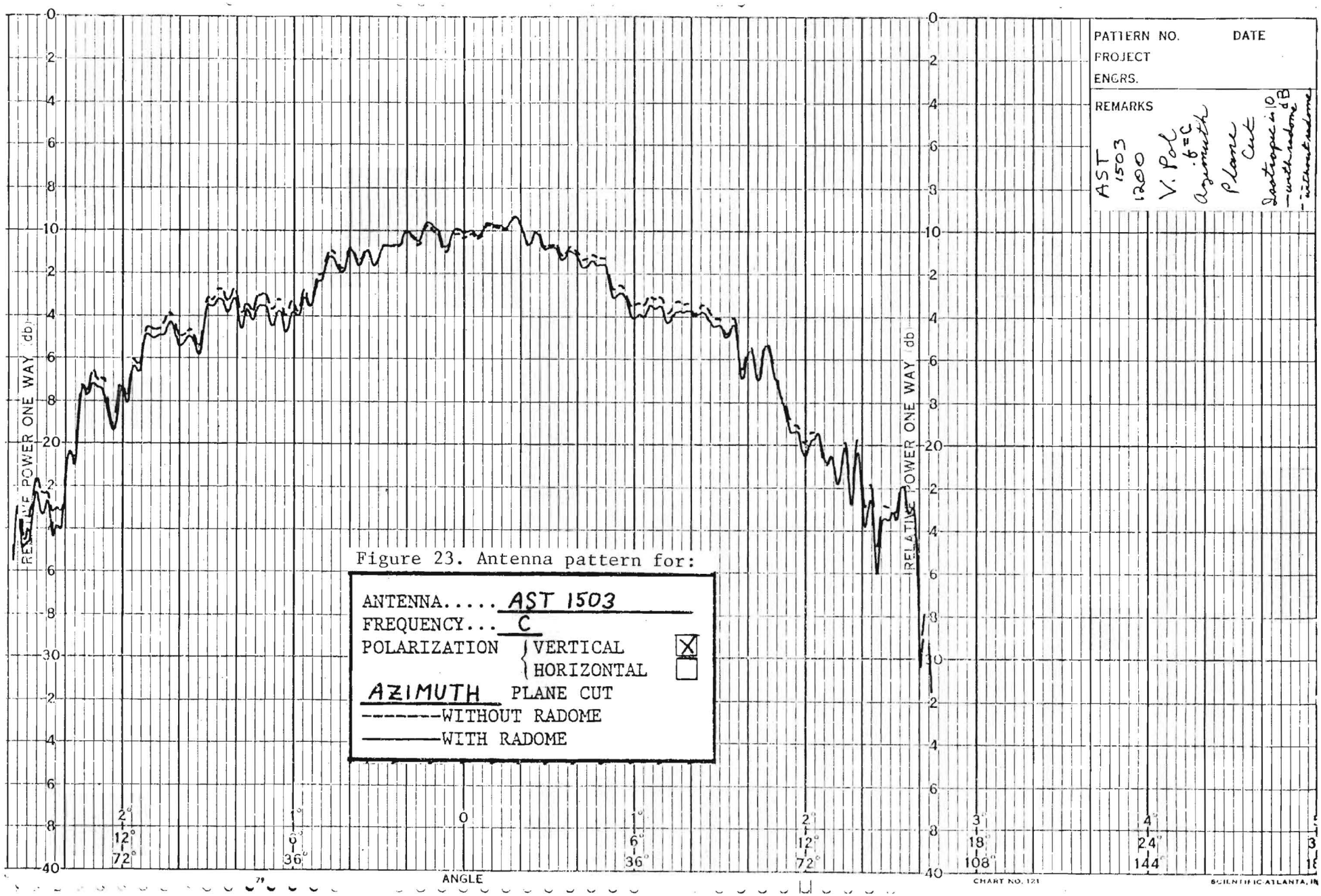


Figure 23. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY... C
POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]

AZIMUTH PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

Figure 24. Antenna pattern for:

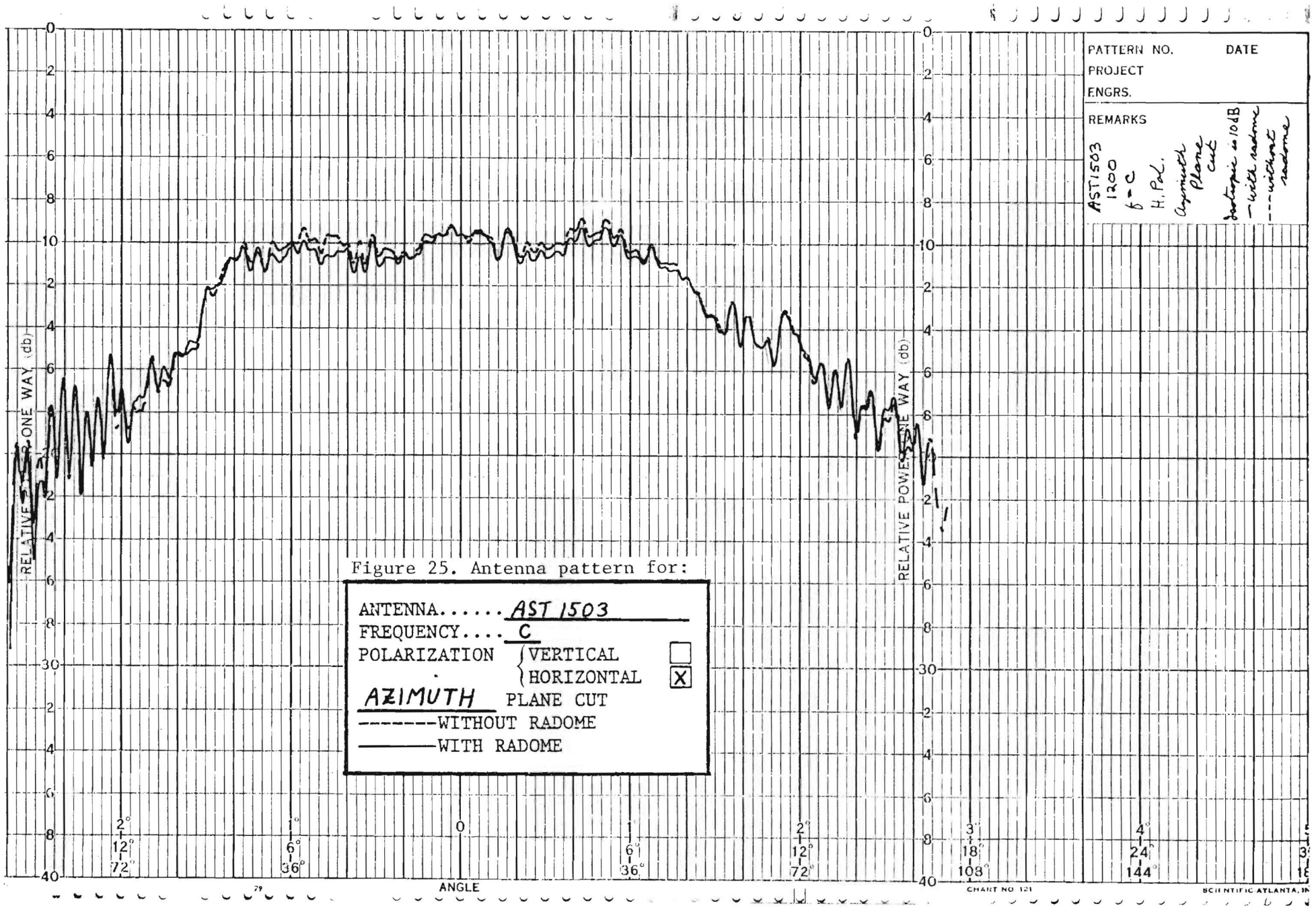


Figure 25. Antenna pattern for:

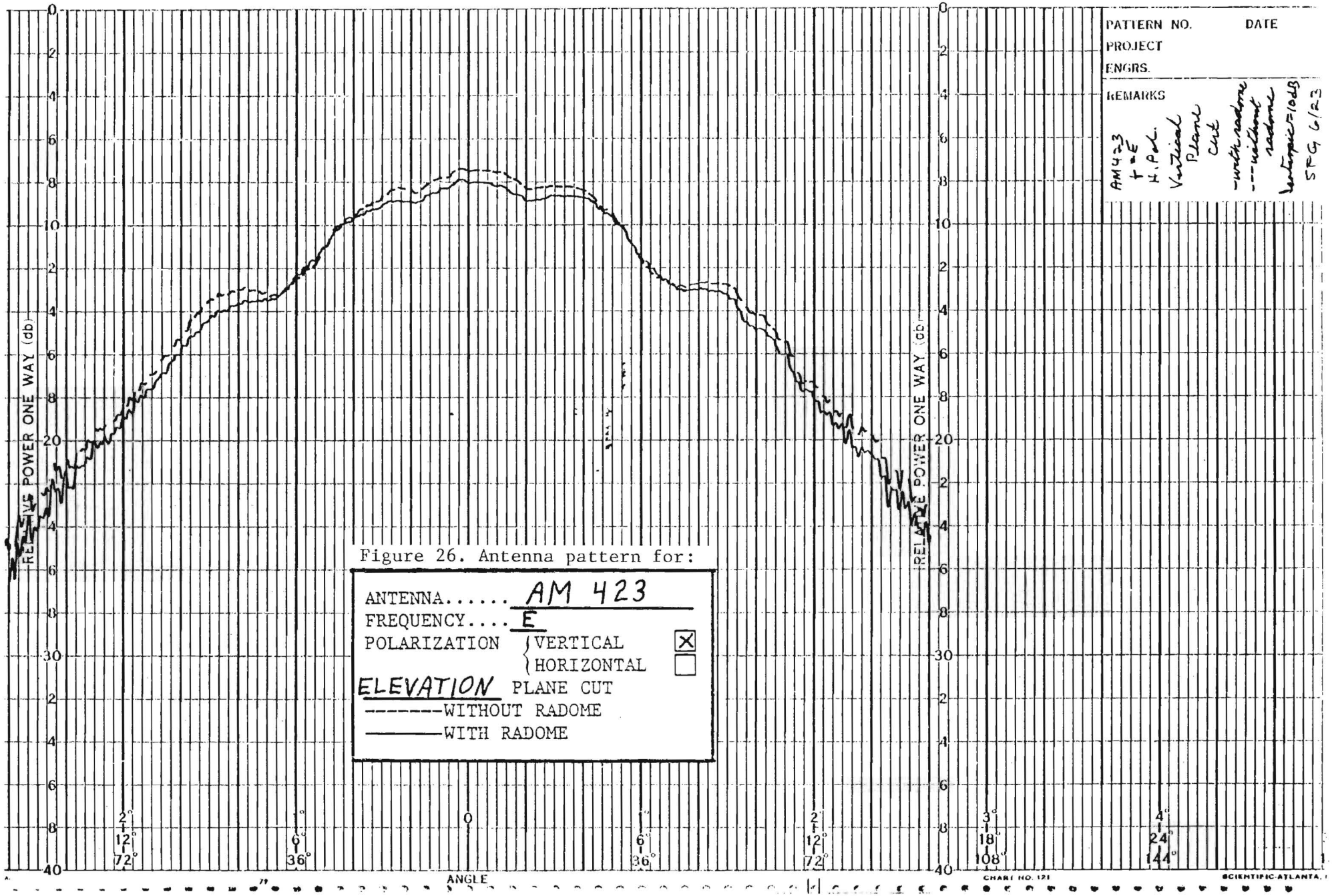
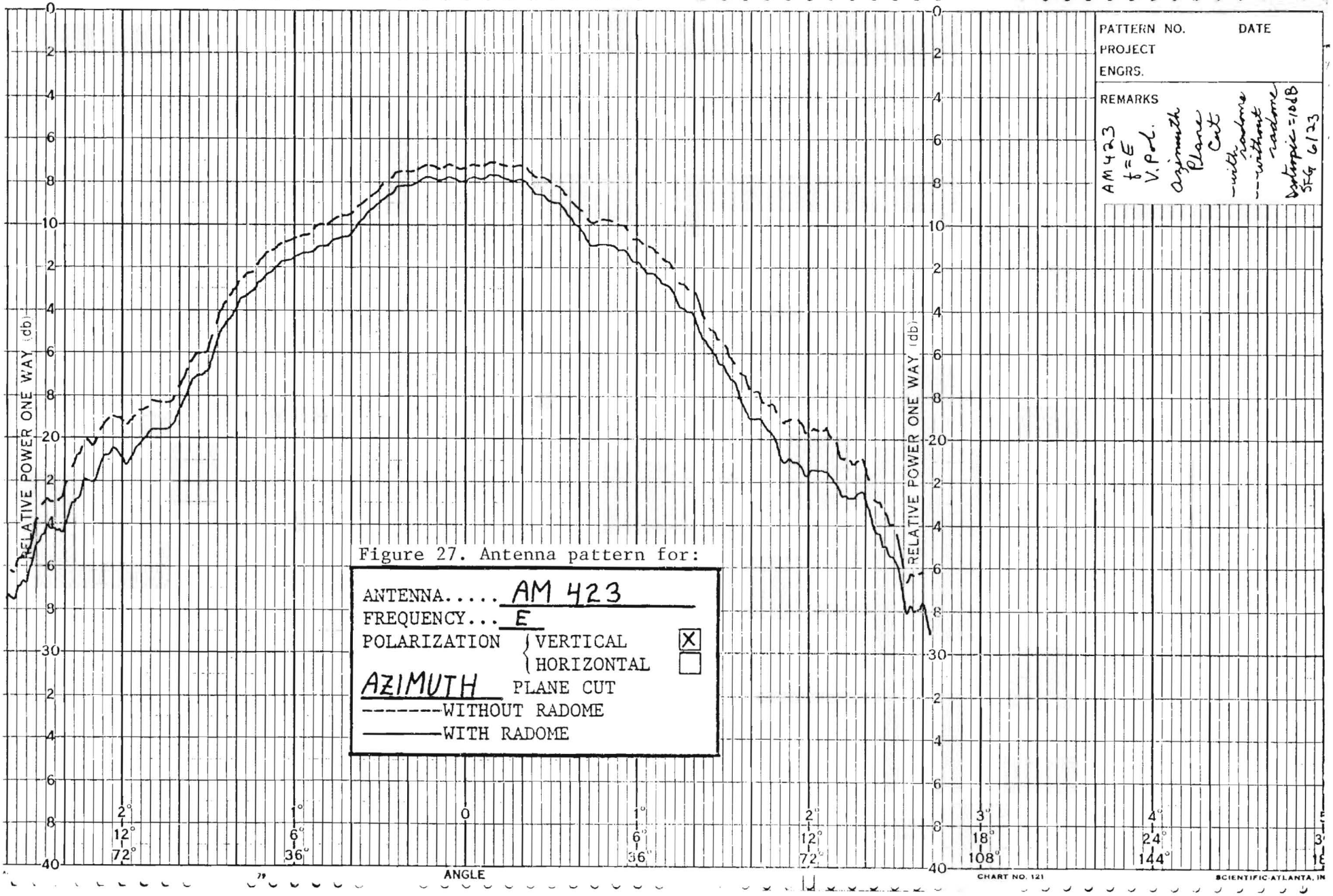


Figure 26. Antenna pattern for:

ANTENNA..... AM 423
FREQUENCY.... E
POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]

ELEVATION PLANE CUT
-------WITHOUT RADOME
————WITH RADOME



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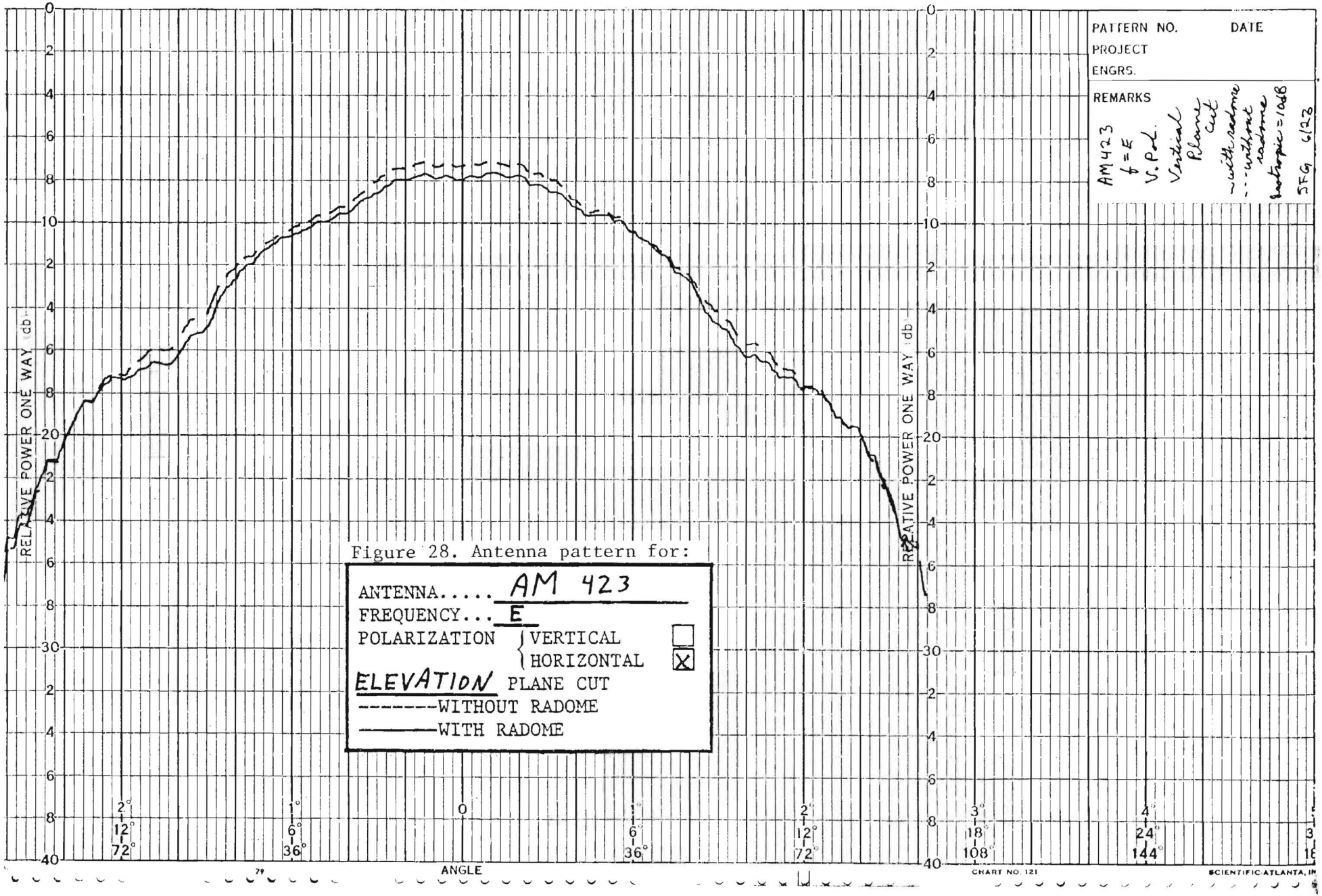
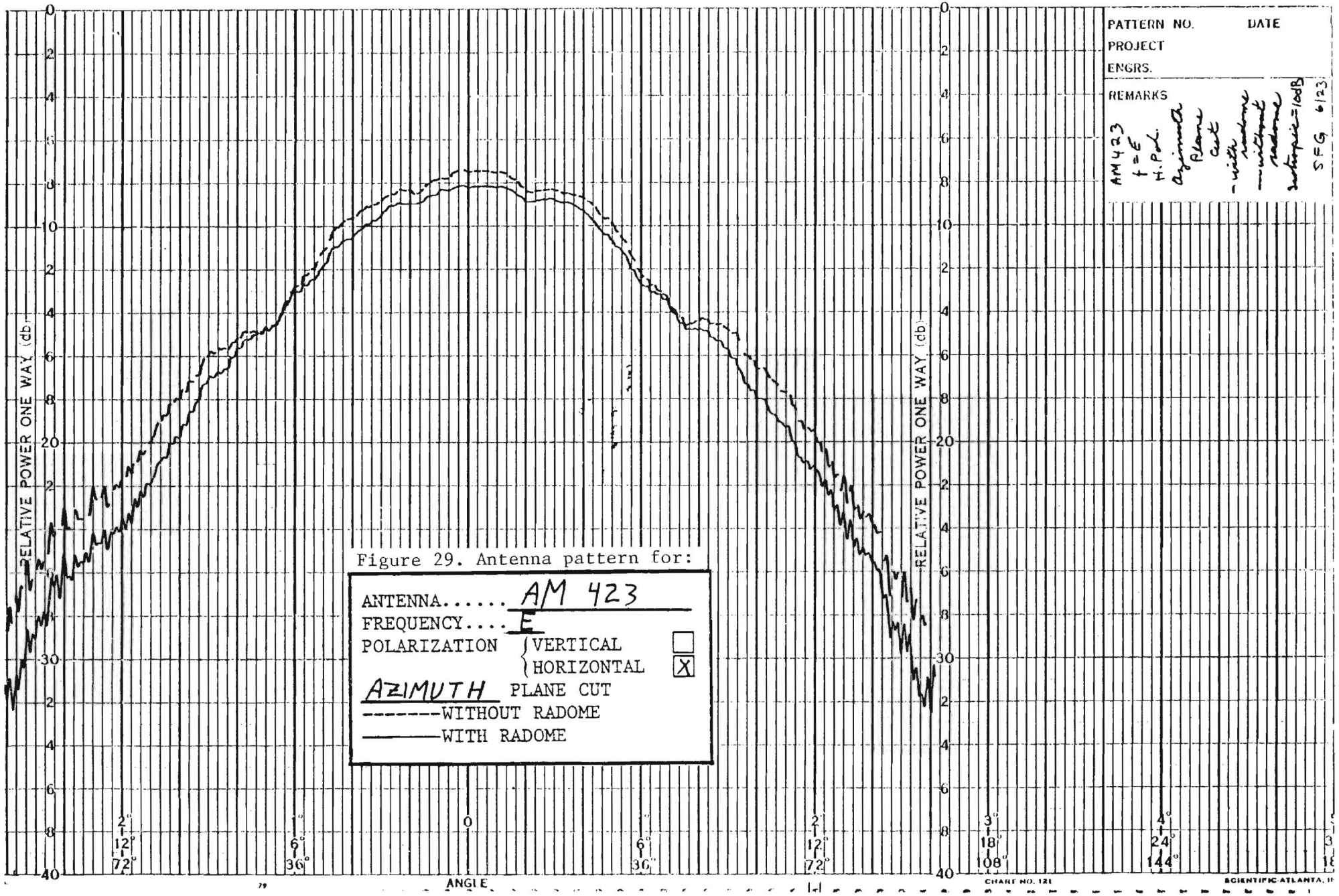


Figure 28. Antenna pattern for:

ANTENNA..... AM 423
FREQUENCY... E
POLARIZATION { VERTICAL ☐
HORIZONTAL ☒



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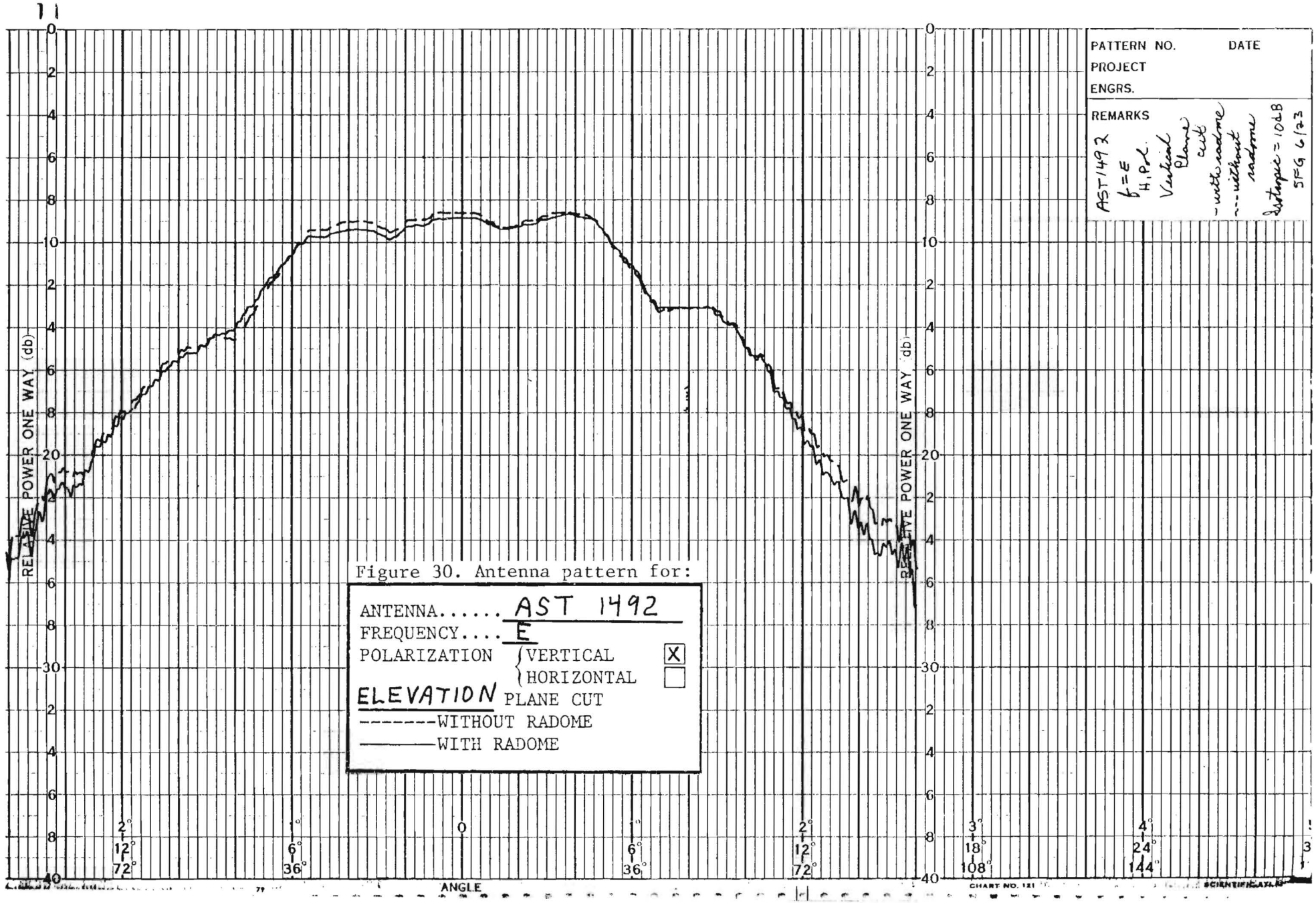

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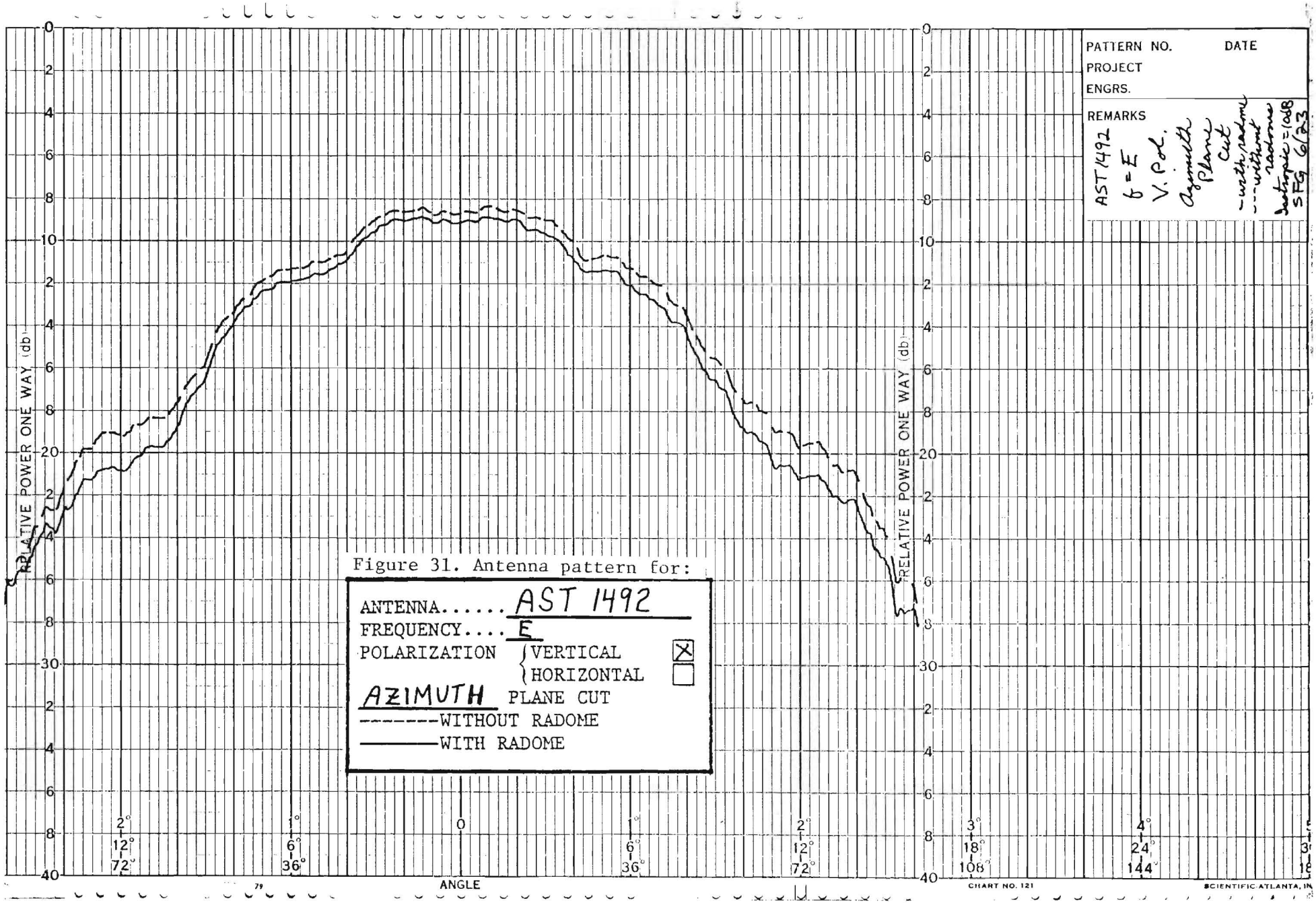

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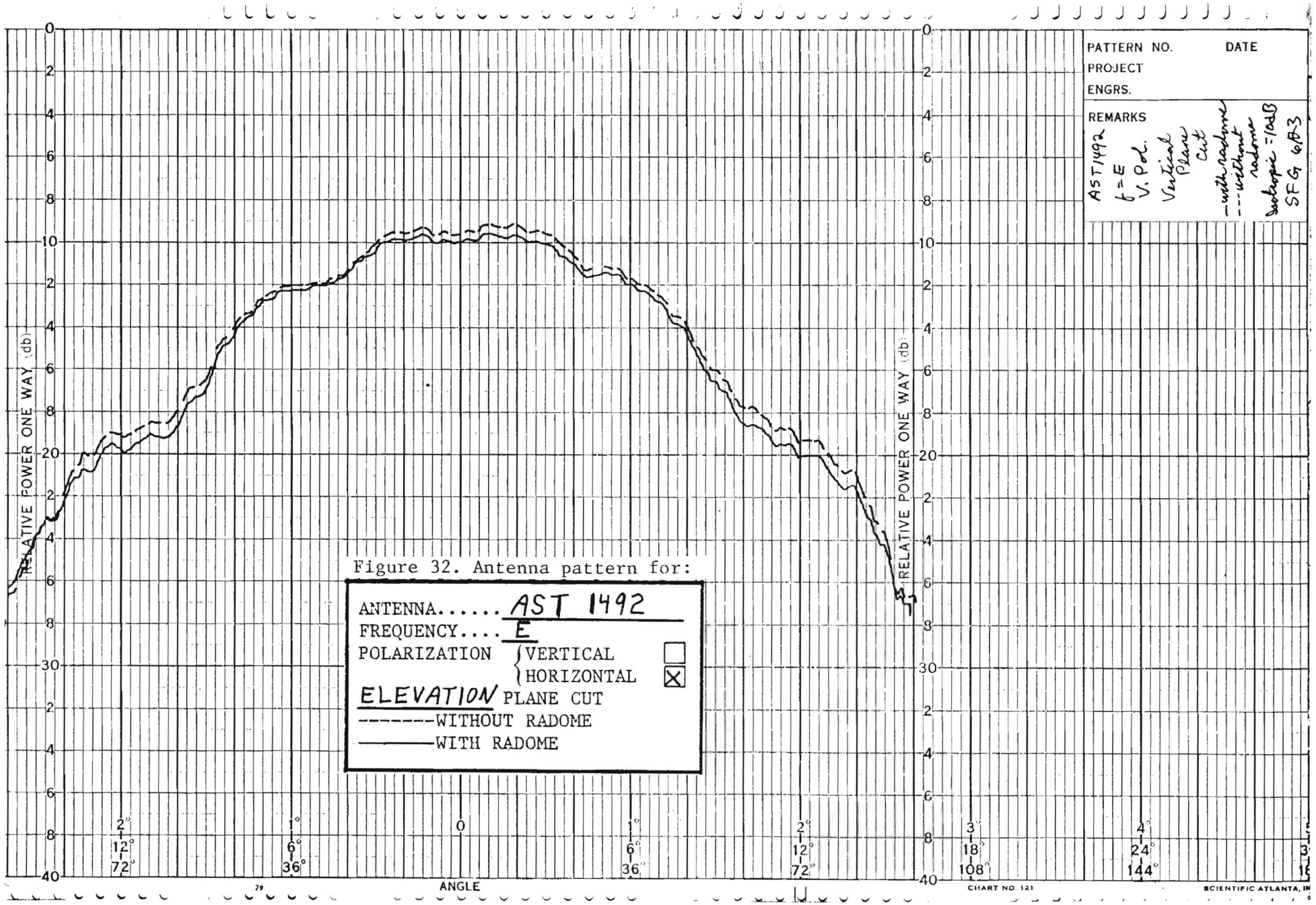
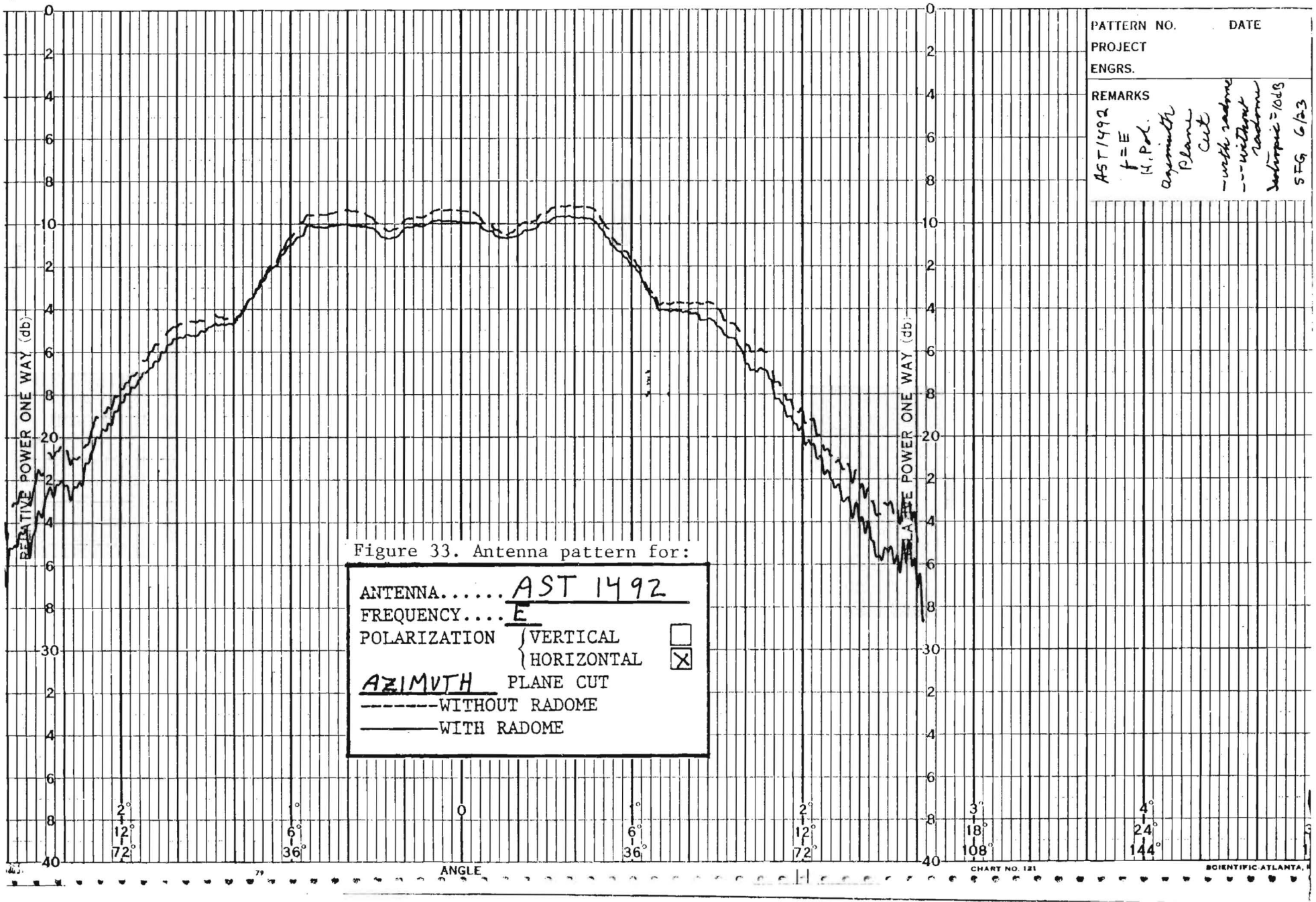


Figure 32. Antenna pattern for:



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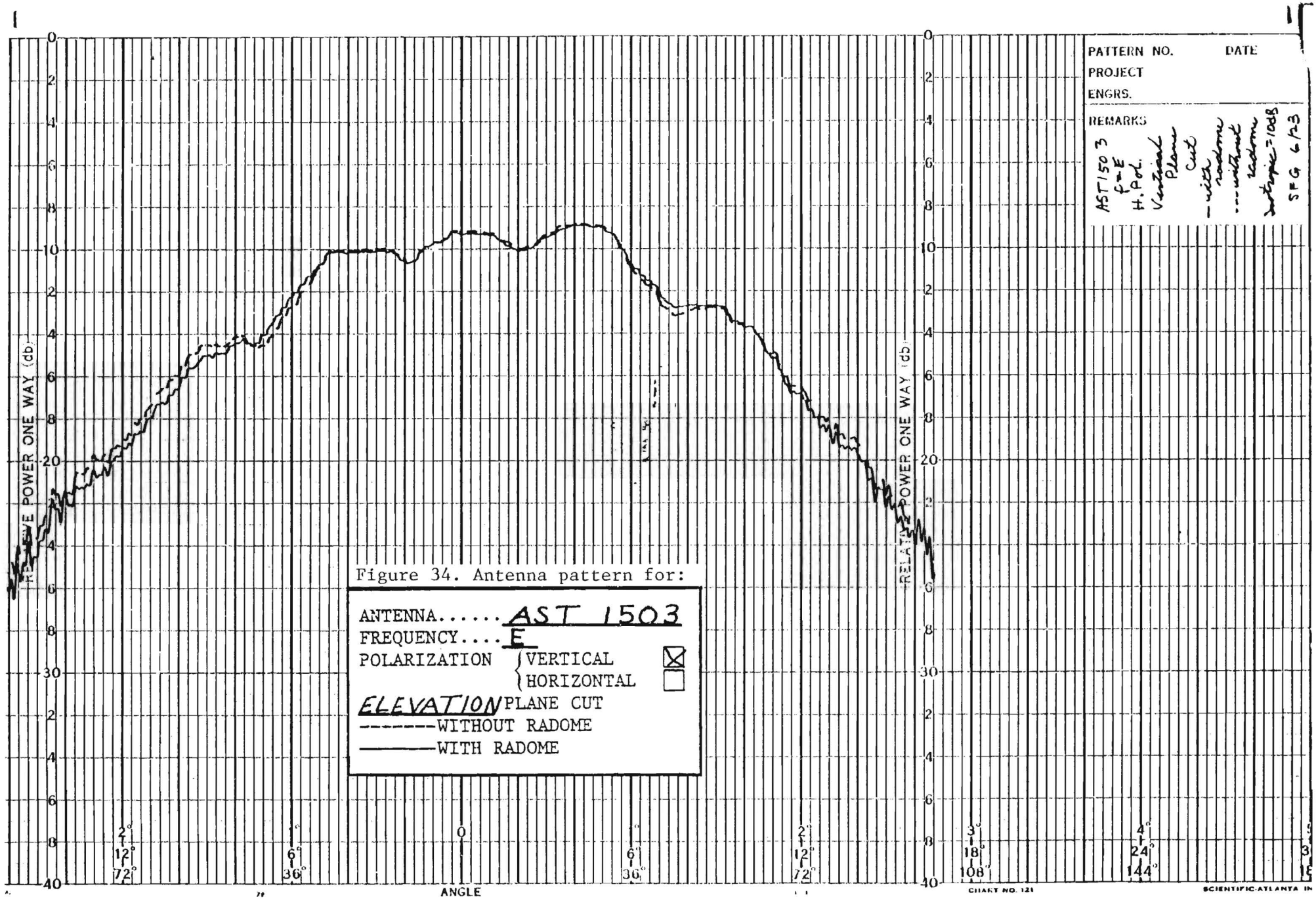

Figure 34. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY.... E
POLARIZATION { VERTICAL ☒ / HORIZONTAL ☐

ELEVATION PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

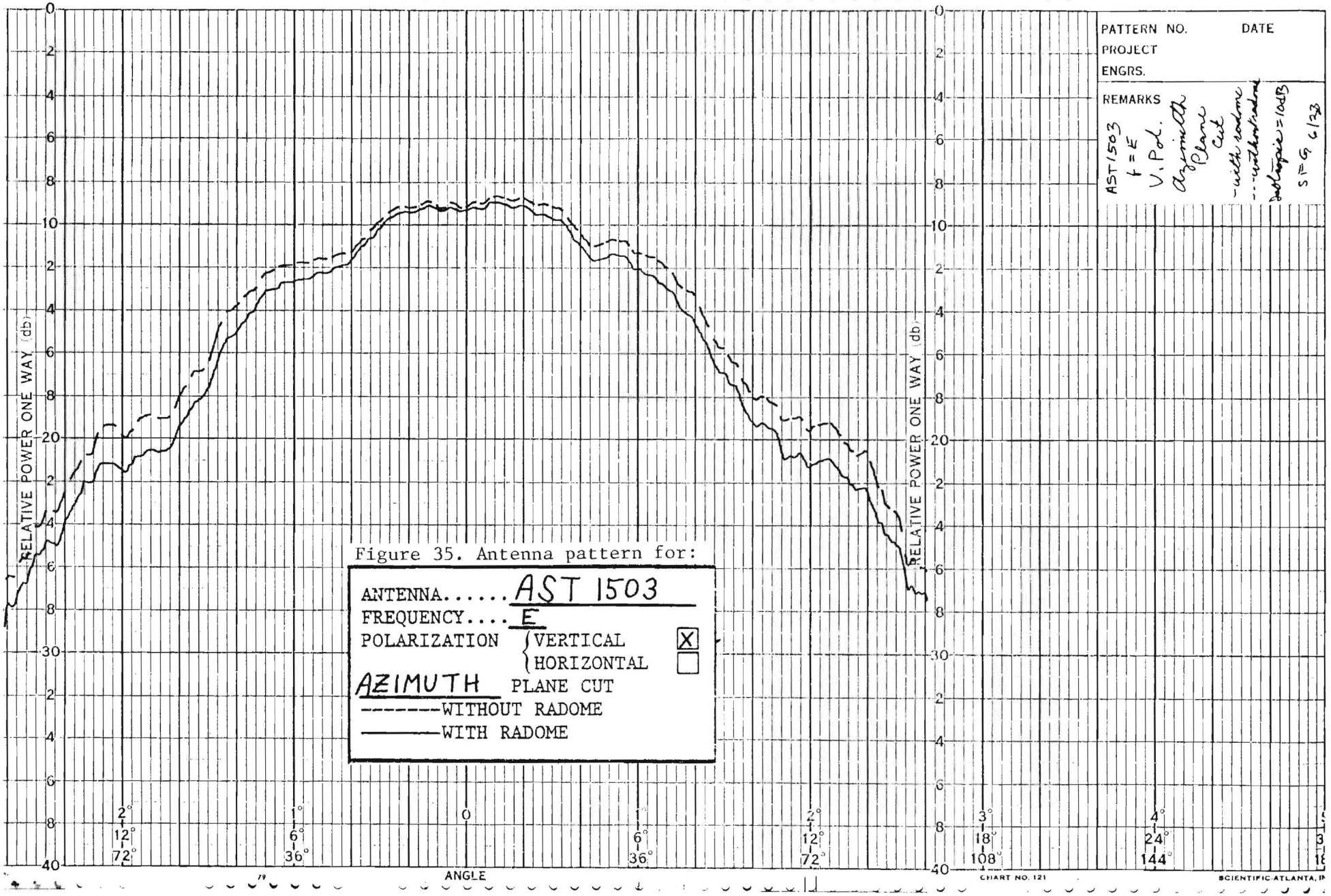

Figure 35. Antenna pattern for:

Figure 36. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY.... E
POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

ELEVATION PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

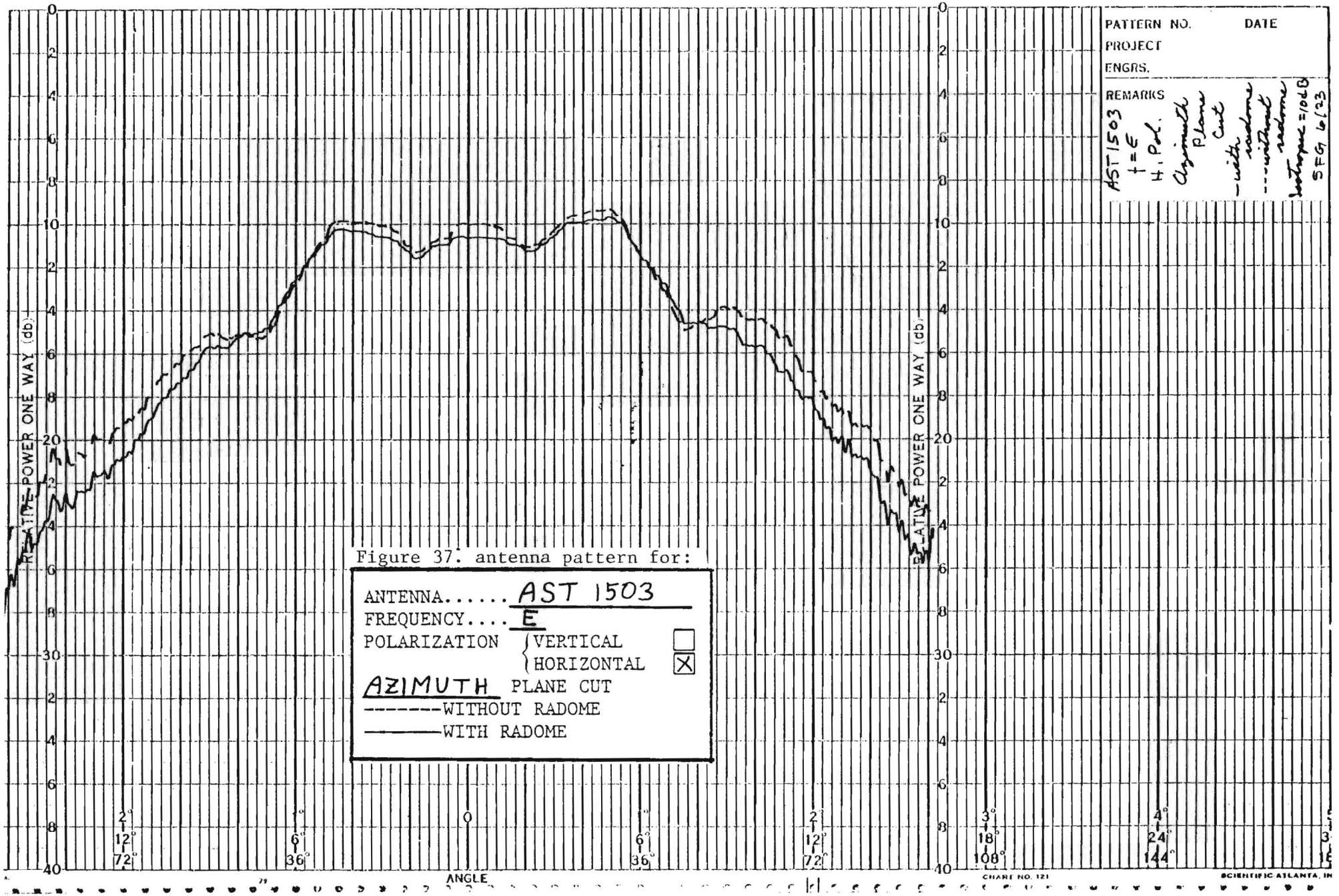

Figure 37. antenna pattern for:

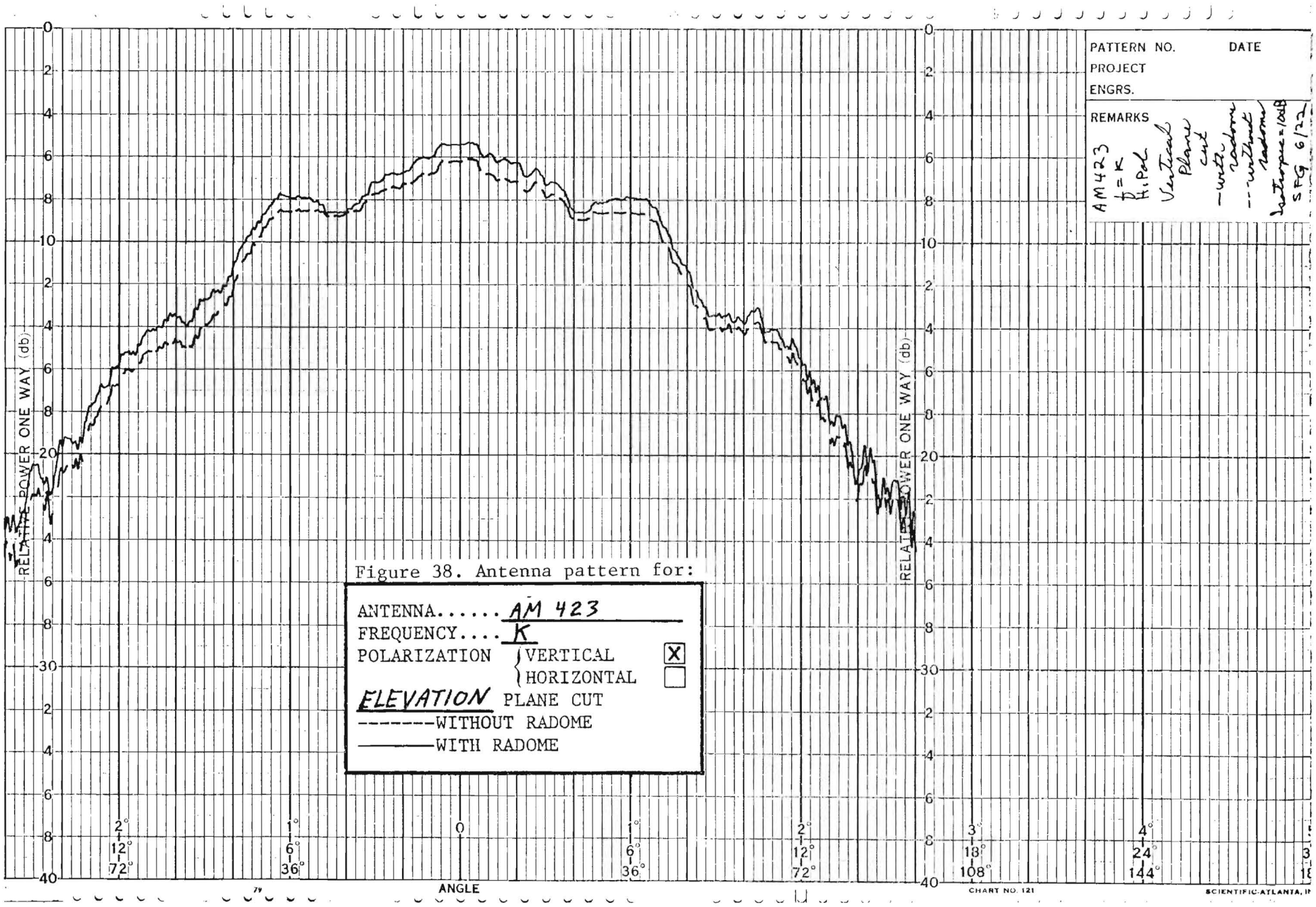

Figure 38. Antenna pattern for:

Figure 39. Antenna pattern for:

ANTENNA..... AM 423
FREQUENCY... K
POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]

AZIMUTH PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

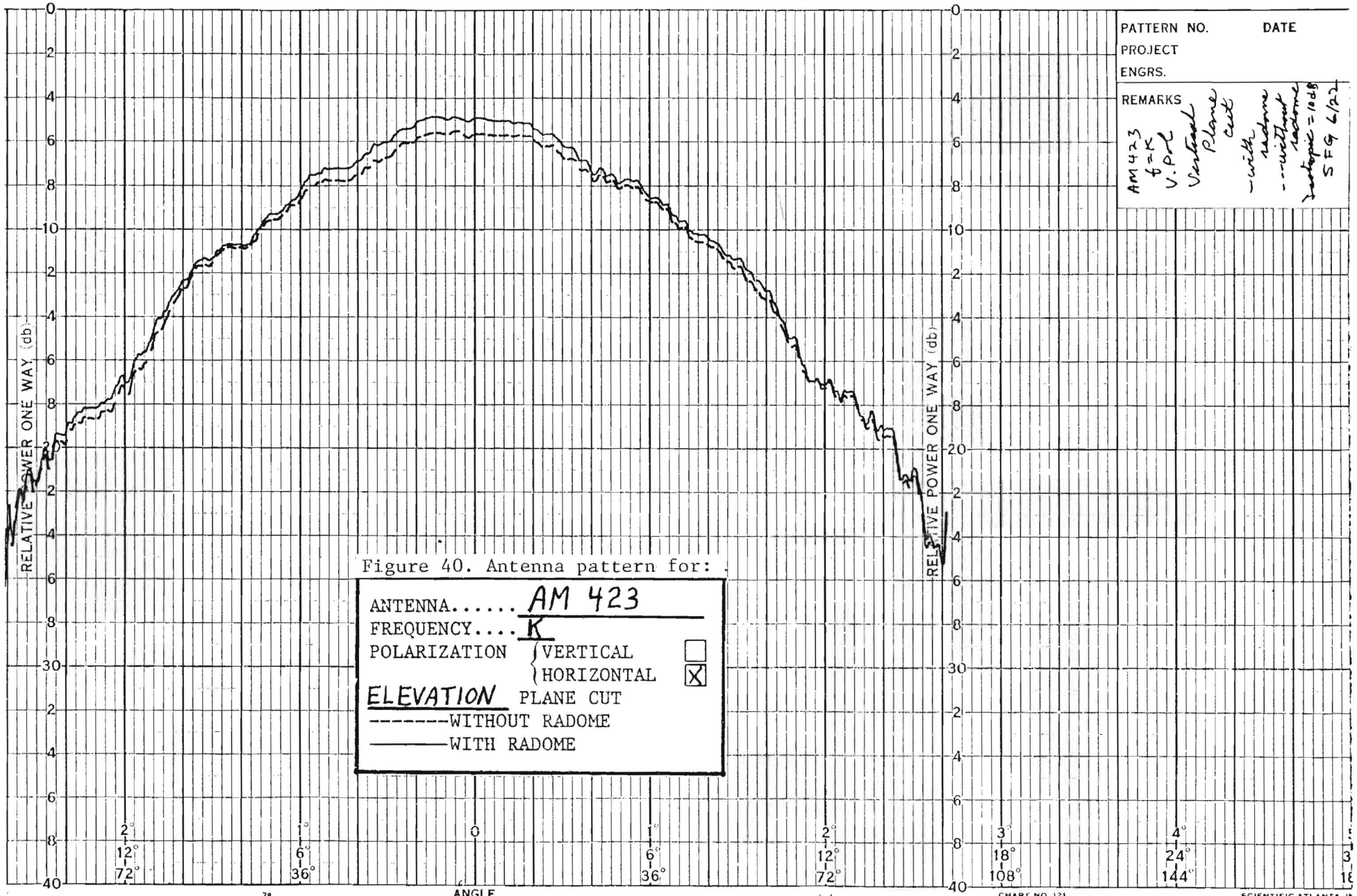

Figure 40. Antenna pattern for:

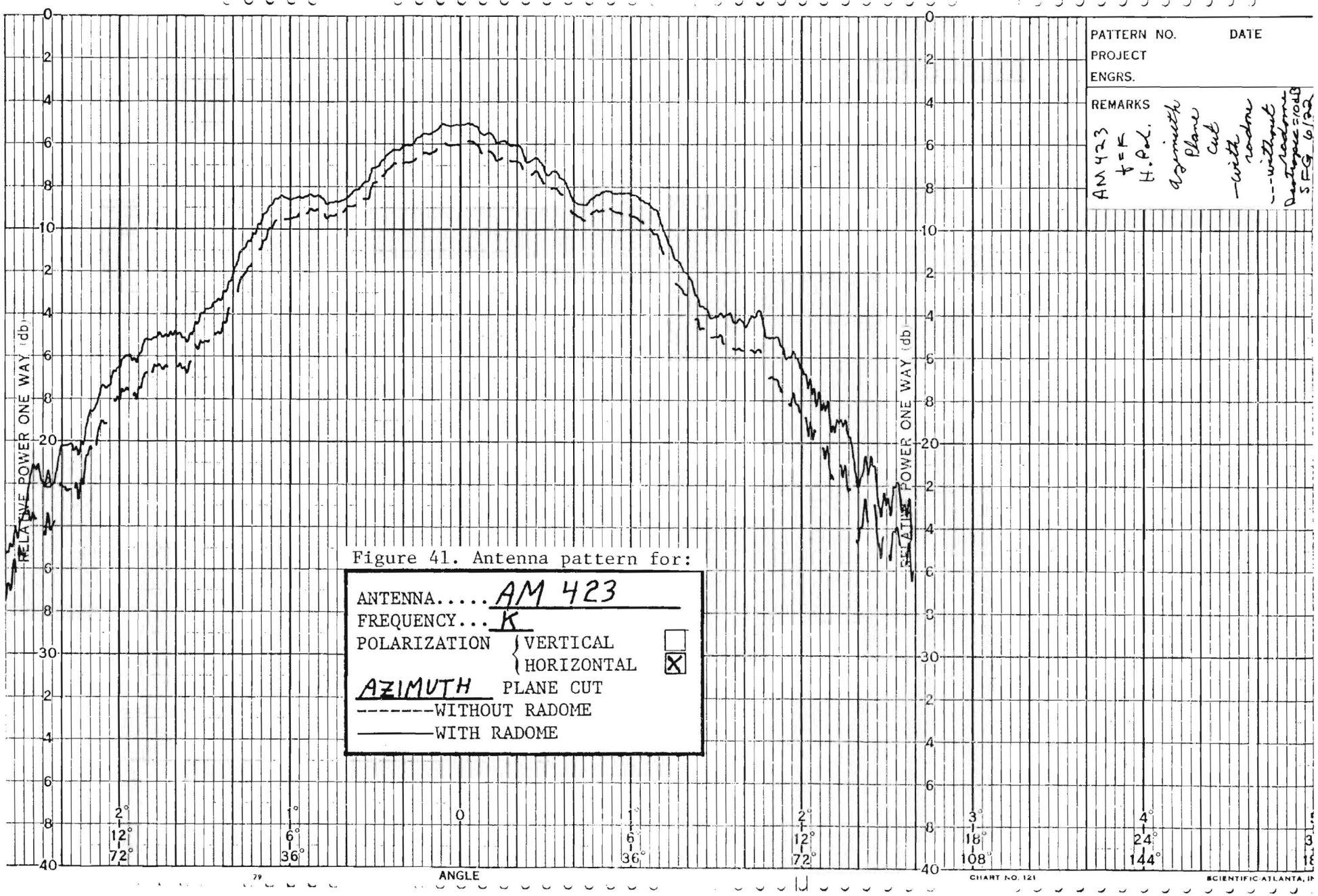

Figure 41. Antenna pattern for:

ANTENNA.....AM 423

FREQUENCY...K

POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

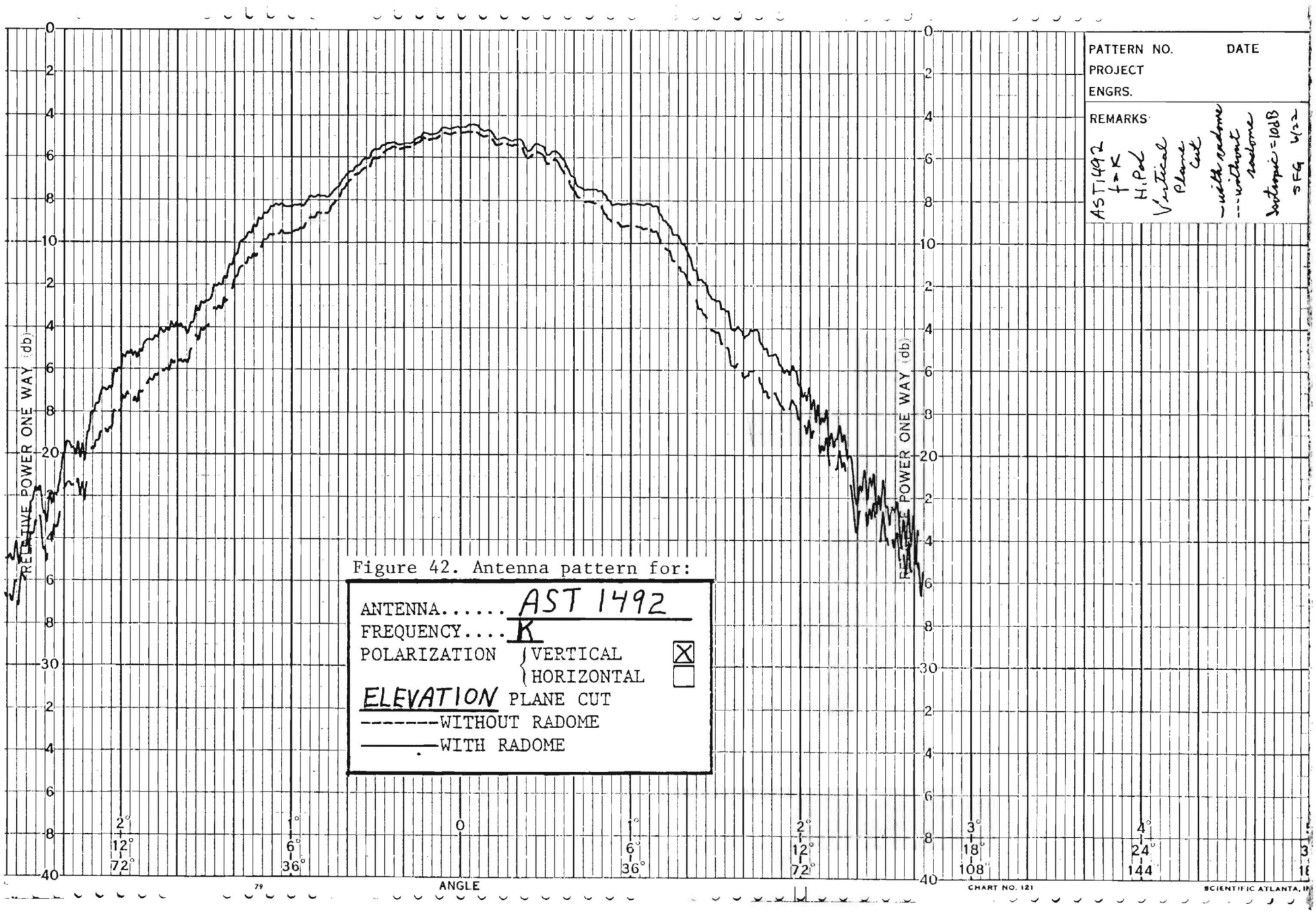

Figure 42. Antenna pattern for:

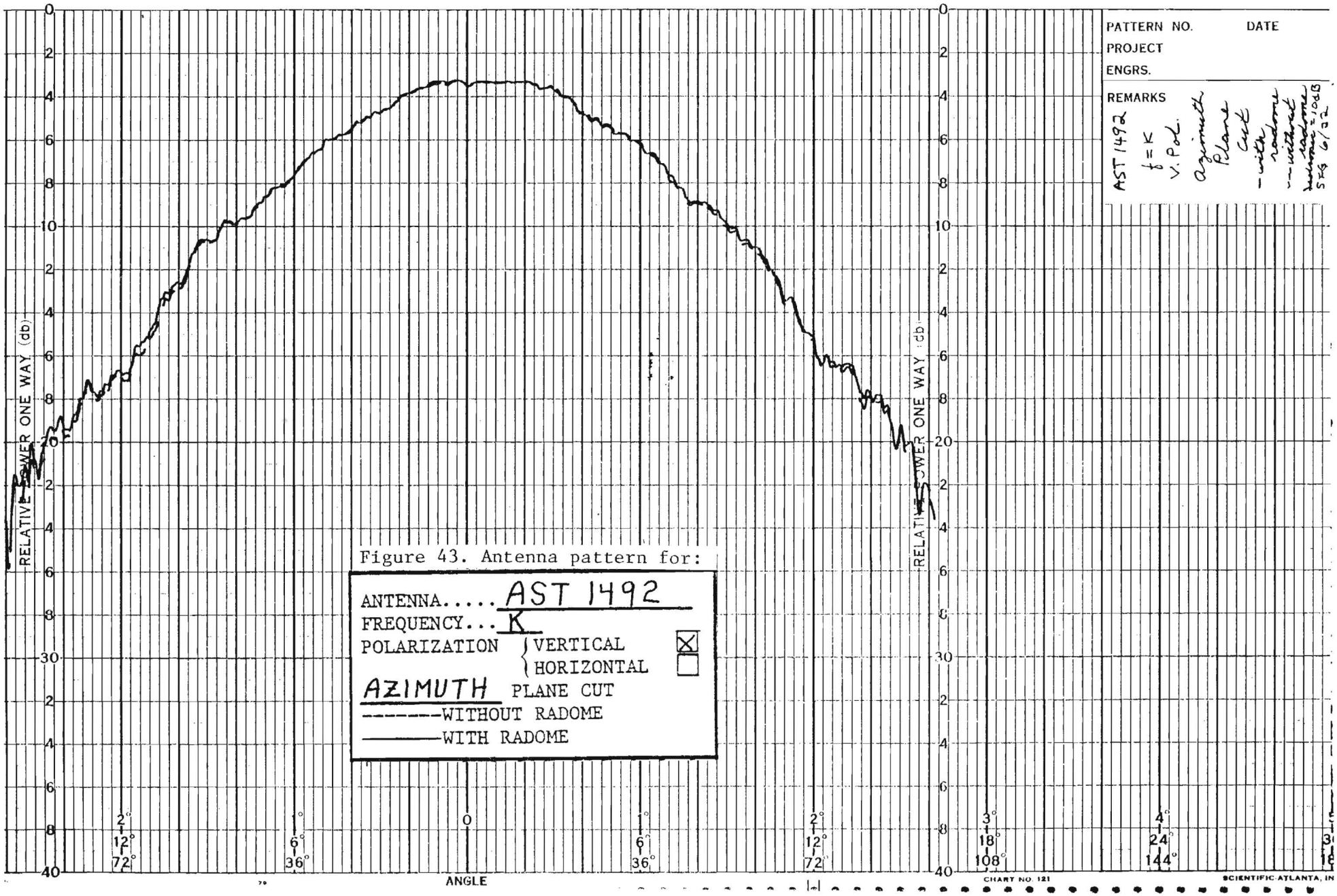

Figure 43. Antenna pattern for:

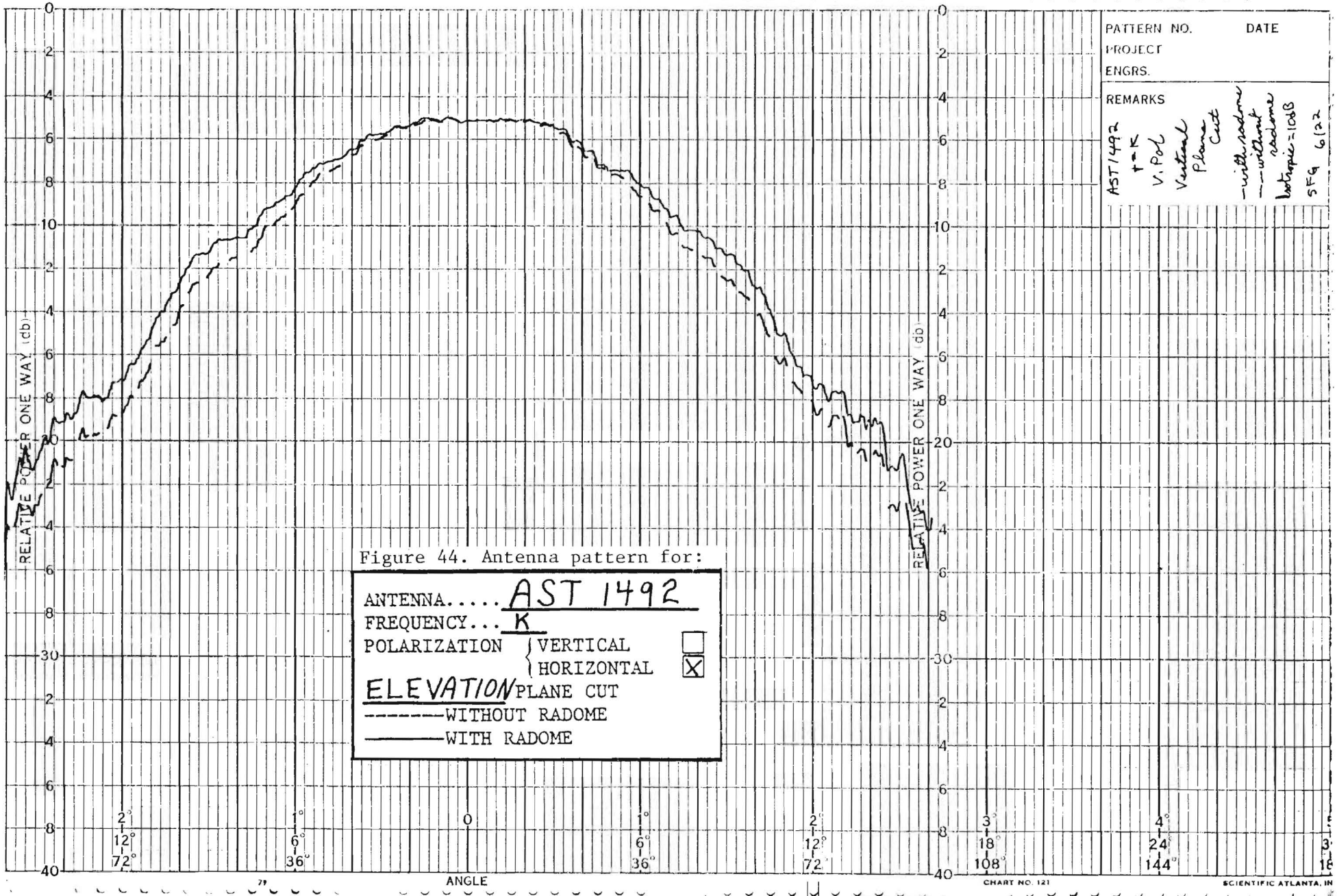

Figure 44. Antenna pattern for:

ANTENNA..... AST 1492
FREQUENCY... K
POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

ELEVATION PLANE CUT

------- WITHOUT RADOME

——— WITH RADOME

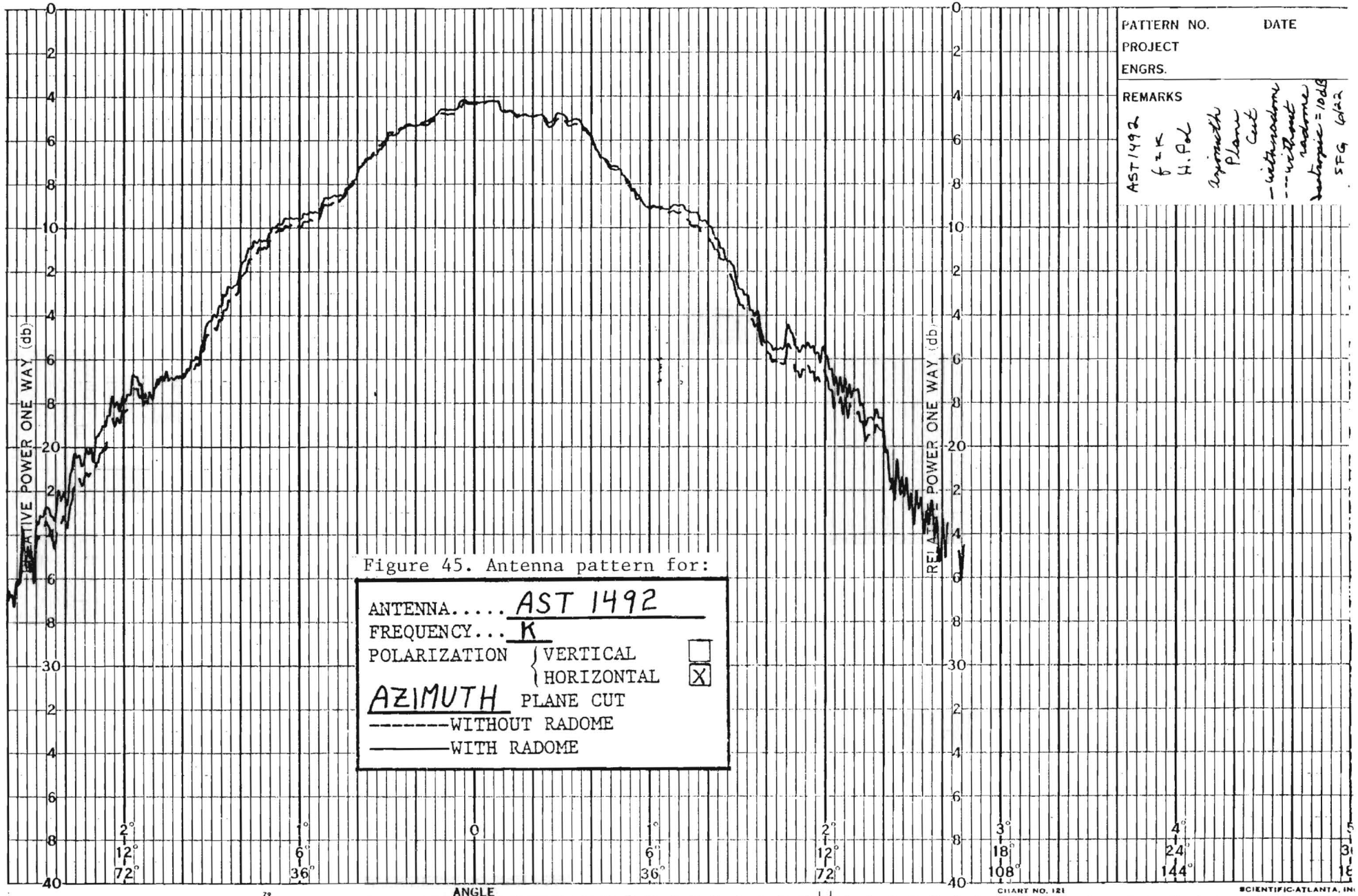

Figure 45. Antenna pattern for:

ANTENNA..... AST 1492
FREQUENCY... K
POLARIZATION { VERTICAL ☐ / HORIZONTAL ☒

AZIMUTH PLANE CUT

-------WITHOUT RADOME

———WITH RADOME

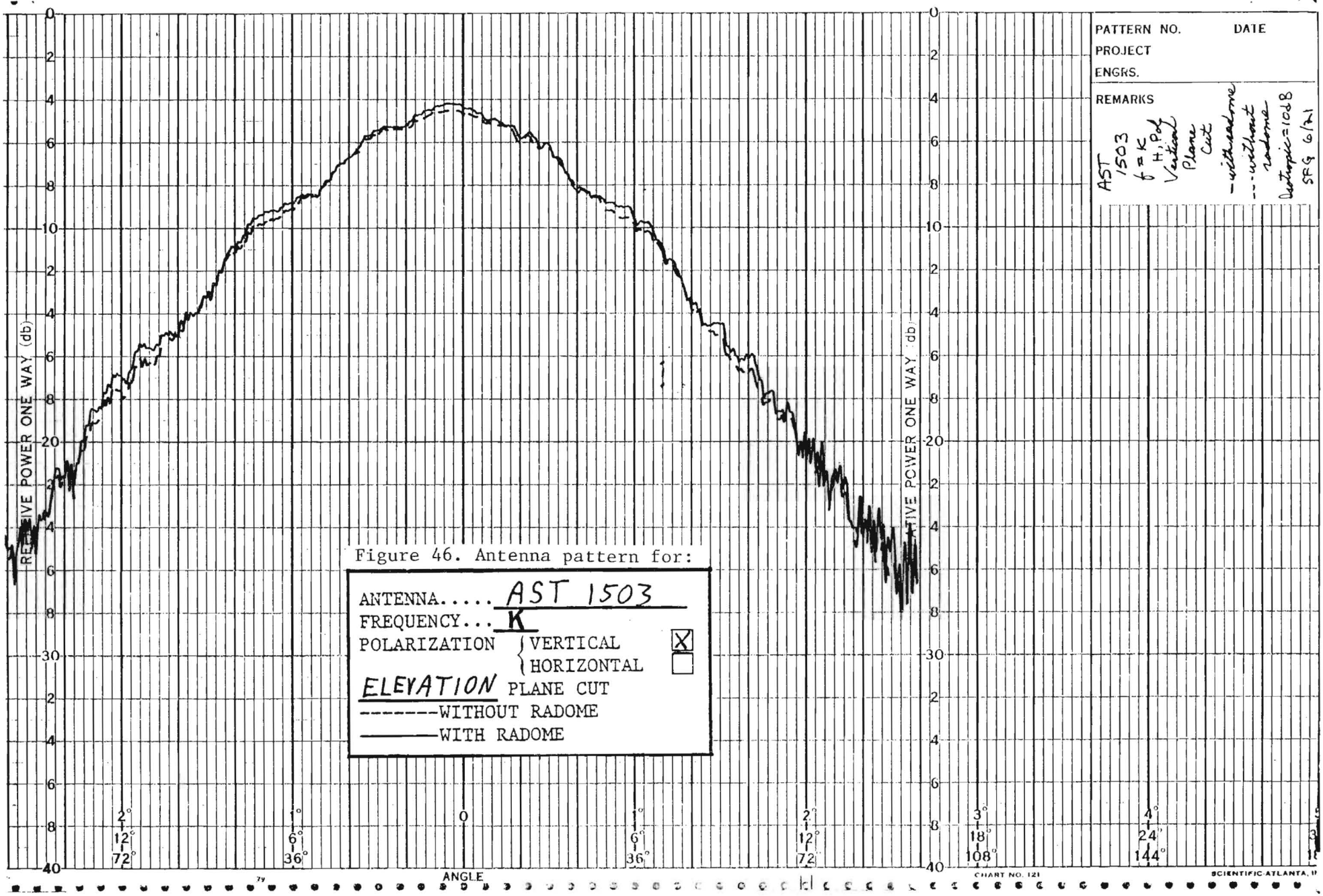

Figure 46. Antenna pattern for:

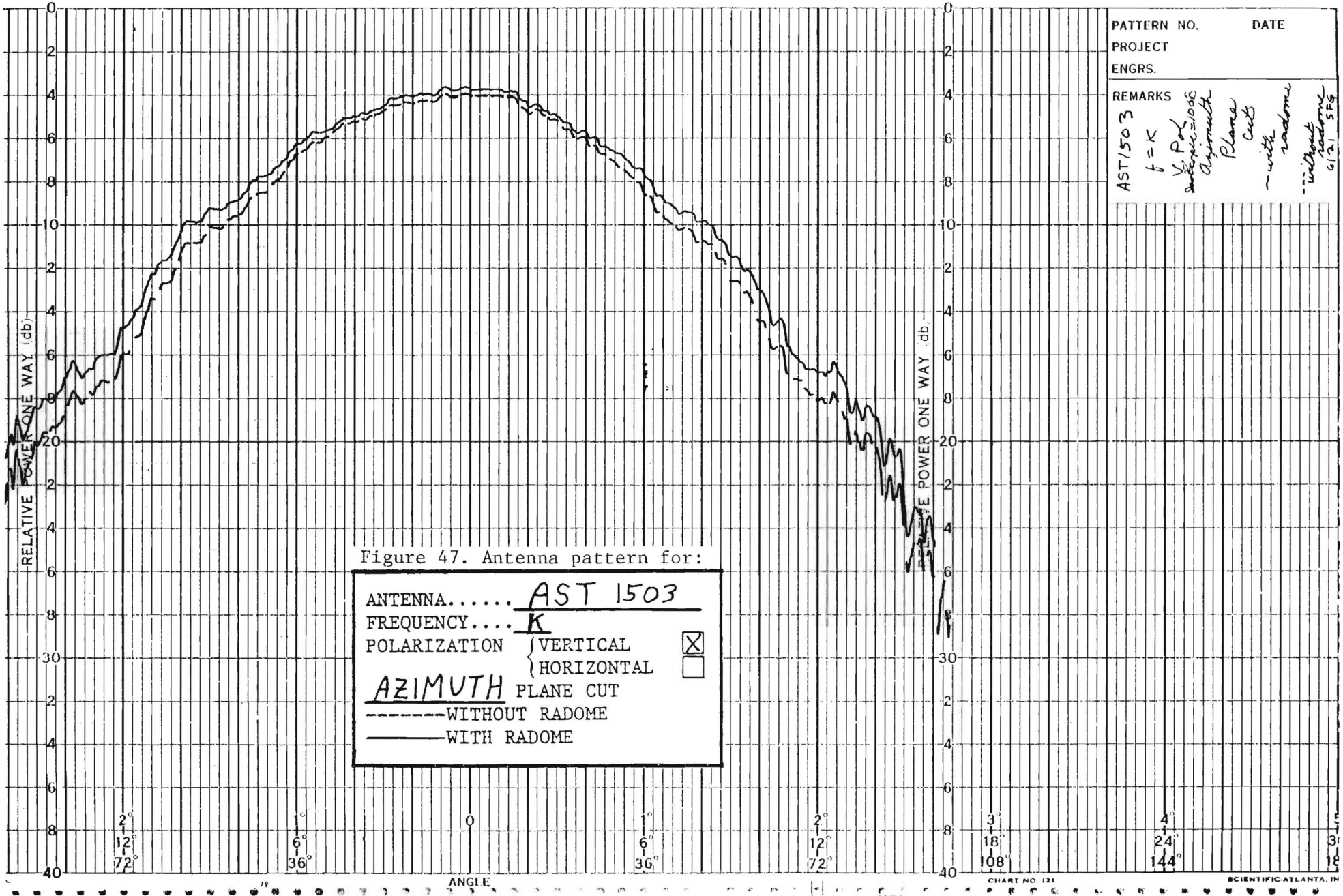

Figure 47. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY.... K
POLARIZATION { VERTICAL [X]
HORIZONTAL [ ]
AZIMUTH PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

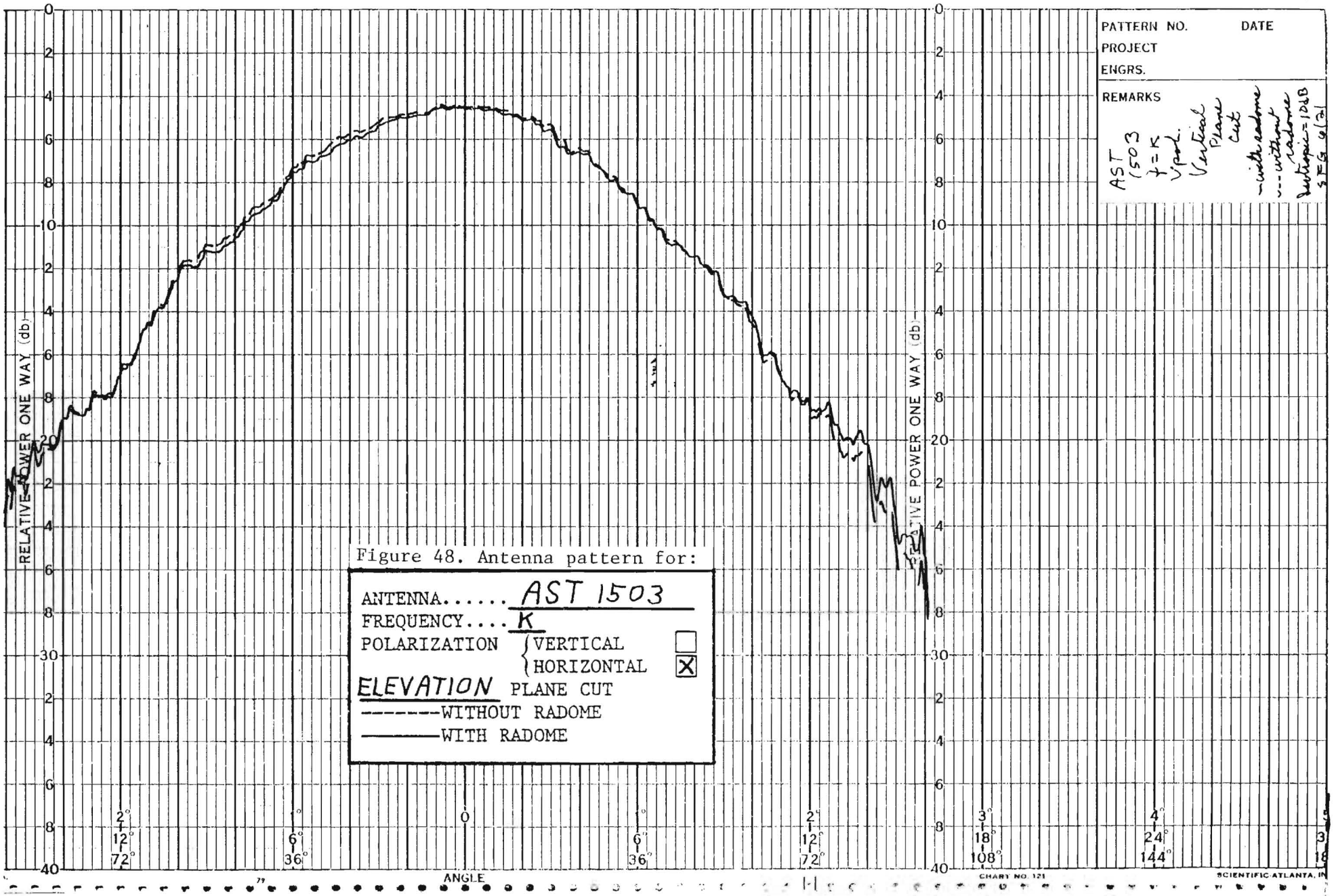

Figure 48. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY.... K
POLARIZATION { VERTICAL ☐
HORIZONTAL ☒

ELEVATION PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

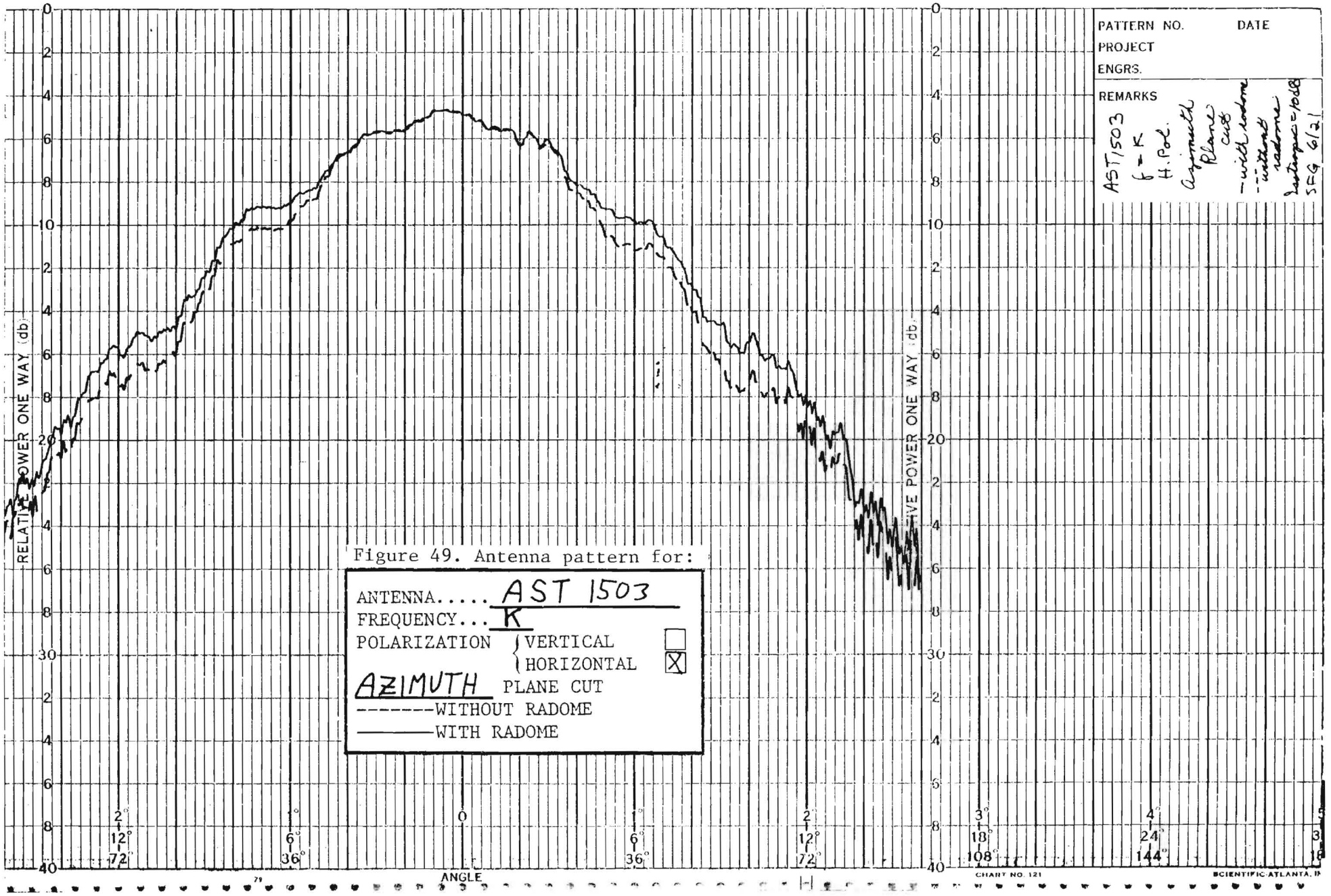

Figure 49. Antenna pattern for:

ANTENNA..... AST 1503
FREQUENCY... K
POLARIZATION { VERTICAL ☐ HORIZONTAL ☒
AZIMUTH PLANE CUT
-------WITHOUT RADOME
———WITH RADOME

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

The patterns presented in this report were measured on a "quick turn around" basis and therefore, are limited in the number of operational frequencies. However, the frequencies selected are representative operating frequencies which span the frequency range. It is recommended, however, (1) that the measurements be extended to cover the entire operating frequency range in finer frequency increments for the selected antennas as well as any other antennas that might be incorporated into the system, (2) that the effects of more than one radome be examined at the higher frequencies, (3) that the polarization purity be spot-checked at several frequencies, (4) that the VSWR of each antenna with and without radomes be measured, and (5) that a uniform set of specifications be devised for specifications of future antenna purchases. Items 1-4 would show which antennas meet current specifications and should be incorporated into the present system, and Item 5 would assure that these problems do not arise again.